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Is moderate beer consumption associated with poor dietary and biochemical parameters of nutritional status in adults? A systematic review of observational and interventional studies with meta-analysis†

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The impact of heavy alcohol consumption on health and nutritional status is well-documented, but the effects of moderate beer consumption remain less well understood. This systematic review and meta-analysis examined evidence on moderate beer consumption and dietary and biochemical parameters of nutritional status. It focused specifically on analysing differences between moderate beer consumers and abstainers. A comprehensive search was conducted across four electronic databases (PubMed, SciELO, Web of Science, and SCOPUS) for studies published in English or Spanish from January 2000 to May 2024. Eligible studies included those examining associations between moderate beer consumption and dietary or biochemical parameters related to nutritional status in healthy adults aged 18 years or older. The systematic review included 16 reports (15 independent samples; nine observational and seven interventional), of which five were eligible for meta-analysis. In most studies, the criteria used to classify individuals as moderate consumers exceeded current recommended guidelines. While some minor differences in dietary parameters were noted, overall diet quality appeared broadly similar between moderate beer drinkers and abstainers, according to the results of the meta-analysis. In both groups, diet quality could be improved, as it deviates from the theoretical ideal. Regarding biochemical parameters of nutritional status, our systematic review found insufficient evidence to draw firm conclusions, as many parameters were assessed in single studies only, making a meta-analysis unfeasible. The relationship between moderate beer consumption and nutritional status parameters remains unclear due to limited and inconsistent evidence. Based on the available data, moderate beer consumption may not be associated with poorer overall diet quality compared to abstention. Nevertheless, these findings should be interpreted with caution due to the substantial heterogeneity and methodological limitations of the included studies. Further research is required to achieve a more comprehensive understanding.

1. Introduction

The impact of moderate alcohol consumption on health remains a subject of considerable debate.[1] Scientific evidence suggests a dose-dependent relationship between alcohol consumption and adverse health outcomes. Long-term heavy intake has been consistently linked to alcohol-related cancers, liver cirrhosis, alcohol dependence, and accidents.[1,2]

However, the effect of low-to-moderate consumption is still controversial due to inconsistent study results, making it difficult to draw definitive conclusions.[3–9]

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Epidemiological studies, nevertheless, suggest a J-shaped relationship between alcohol consumption and the risk of mortality, and cardiovascular, and neurodegenerative diseases, with lower risks observed in moderate drinkers.[7,8,10]

Some studies have suggested that the type of beverage may modulate this relationship, particularly in the case of wine or beer.[7,10]

Nevertheless, the Global Burden of Disease (GBD) 2016[11] reported that the amount of alcohol required to minimise health risk is zero. Similarly, the GBD (2020) report[1] reiterates the recommendation of zero alcohol consumption for all population groups, particularly for younger individuals (<40 years old). However, the same report notes that small amounts of alcohol may benefit populations with high cardiovascular risk, particularly older adults, though effects vary across regions of the world.[1]

In Spain, based on the review of cohort studies with minimised bias, low-risk alcohol drinking limits have been set at 20 g day^{-1} for men and 10 g day^{-1} for women, assuming there is no zero risk.[2] This is in line with recommendations from other European countries, including Portugal, Germany, Italy, France, and Norway, which define low-risk thresholds around 20 to 24 g day^{-1} of alcohol for men, and 10 to 16 g day^{-1} of alcohol for women.[2]

The health effects of alcohol may not depend solely on the quantity consumed; drinking patterns also appear to play a significant role. Evidence suggests that the effects of alcohol may vary depending on the type of alcoholic beverage (*e.g.*, beer, wine, distilled spirits), the pattern (regular *vs.* binge), quantity, and whether it is consumed with meals.[8,12,13]

Despite similarities with other fermented beverages such as wine, beer presents distinctive features that justify a specific focus. It is one of the most widely consumed alcoholic beverages and is part of the dietary habits of various cultures and societies around the world.[14,15] In Mediterranean countries, compared to other northern European countries, beer is typically consumed in moderation, often with meals and within the socio-cultural context of family and friends. This pattern has garnered attention, as it differs from other drinking styles and may modulate the health effects of alcohol consumption.[6,9]

Growing interest has emerged over the past decade in analysing moderate beer consumption from both nutritional and health perspectives. While some studies have focused on differences in dietary habits according to the type of alcoholic beverage consumed,[3,5] others have explored the potential role of moderate beer intake, particularly within the context of the Mediterranean dietary pattern, in the prevention of chronic diseases.[7,9] Some observational evidence suggests that moderate beer consumption may exert similar protective effects, particularly in relation to cardiovascular and neurodegenerative diseases, as well as all-cause mortality.[6,7,9]

However, most of these studies have focused on clinical outcomes, while the potential intermediary role of nutritional status remains understudied. This gap was also highlighted in the 2024 National Academies report,[16] which found insufficient evidence on the nutritional implications of alcohol intake and did not explore dimensions of nutritional status beyond weight and adiposity.

Potential health benefits have also been linked to antioxidant and anti-inflammatory properties,[15] improvement in blood lipid profile[17,18] and gut microbiota.[15] In fact, fermented beverages like beer have shown health advantages not observed with distilled spirits, even when consumed in similar amounts.[3,5,15] These effects have been attributed to non-alcoholic components of beer, which may play a direct role in influencing nutritional status and help explain its potential mechanisms of action.[4]

Beer contributes to the overall dietary intake by providing energy, carbohydrates, proteins, vitamins (such as folate and choline), and minerals (such as calcium, phosphorus, magnesium, iron, zinc, selenium, potassium, sodium, copper, manganese, fluoride, and silicon).[7,9,15] It also contains other bioactive compounds such as phenolic compounds derived from malt and hops (*e.g.*, catechins, epicatechins, proanthocyanidins, ferulic acid, isoxanthohumol, xanthohumol, quercetin, and rutin), which result from the raw material or brewing process.[7,9,15]

Furthermore, moderate beer consumption has been reported to potentially exert an indirect influence on nutritional status, primarily through its association with healthier dietary habits, which may play a mediating role in the potential health effects of beer consumption.[5]

While many studies have examined the potential health benefits of moderate beer consumption,[6,7,15] considerably fewer have specifically addressed its impact on nutritional status. To the best of our knowledge, only three studies have addressed related aspects: one systematic review and meta-analysis examined the association between moderate beer consumption and both abdominal and general obesity;[19] another systematic literature review analysed the relationship between alcoholic beverage preferences (including beer) and dietary habits;[20] and a third study explored the effect of alcohol consumption on food energy intake, regardless of beverage type.[21]

To date, no reviews have comprehensively summarised the evidence on the influence of moderate beer consumption on dietary and biochemical indicators of nutritional status. Given the ongoing debate on moderate alcohol consumption, updated evidence is essential to better understand its potential impact on dietary patterns and nutritional status.

This systematic review and meta-analysis therefore sought to analyse the available scientific evidence regarding moderate beer consumption and its association or effect on dietary and biochemical parameters of nutritional status. Furthermore, we aimed to identify differences between moderate beer drinkers and abstainers in the parameters studied.

2. Materials and methods

2.1. Protocol and registration

This systematic review and meta-analysis was conducted following the methodological guidance of the Cochrane Handbook for Systematic Reviews of Interventions[22] and reported following the *PRISMA 2020* statement (Preferred

Reporting Items for Systematic Reviews and meta-Analyses).[23] The systematic review protocol was registered in PROSPERO (CRD42023407762) and is available at **https://www.crd.york.ac.uk/PROSPERO/view/CRD42023407762**.

2.2. Eligibility criteria

The selection of studies was based on the following inclusion criteria:

(i) Human studies conducted in healthy populations ≥18 years old;

(ii) Observational studies (cross-sectional, case-control and cohort studies) and interventional studies (randomized controlled trials, non-randomized controlled trials, no controlled trials (pre and post)) studying the association or effect of moderate beer consumption and dietary patterns and/or nutritional status parameters;

(iii) Studies must address the analysis of moderate beer consumption based on at least one of the following criteria:

• Studies that provide an explicit definition of 'moderate alcohol consumption', specifying the daily alcohol intake thresholds used to categorize consumption as moderate even if the definition was not entirely consistent with current low-risk drinking guidelines, and that reported results specifically for beer.

• Studies in which the authors described participants' alcohol consumption as moderate, even in the absence of an explicit threshold, provided that beer intake was reported separately and remained below 40 g day^{-1} for men and 20 g day^{-1} for women.

(iv) Studies must include a beer consumption group category according to one of these criteria:

• Studies that report outcomes based on categories of alcohol or beer consumption, including a defined moderate consumption category, and provide data specific to beer among participants who have beer as their preferred alcohol beverage (≥50% of the total alcohol intake from beer).

• Studies that report outcomes based on drink preference (including beer), among participants who have a moderate beer consumption and as their preferred alcohol beverage (≥50% of the total alcohol intake from beer).

• Studies that report interventions based on the administration of moderate amounts of beer.

(v) Studies must include an abstainer group defined as:

• Life-long abstainers.

• Individuals who have not consumed alcohol in the last 12 months.

• Individuals with a history of low alcohol consumption.

• Occasional consumers (defined as those who consume less than four alcohol drinks per month).

• Individuals who received water or alcohol-free beer (control group) in interventional studies.

(vi) Studies must include some of the following outcomes:

• Dietary parameters of the nutritional status: dietary patterns, diet quality indices (such as MEDAS, HEI…), food consumption (expressed as grams per day or servings per day, frequency of consumption), energy intake, energy without alcohol, nutrient intake (expressed as grams per day or percentage from total energy intake (%TEI)), protein intake, vegetal protein, carbohydrate, fibre, fat, saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), cholesterol, vitamins and minerals.

• And/or biochemical parameters of the nutritional status parameters: fatty acids, vitamins and minerals, among others (measured in serum, urine, or other biological samples).

(vii) Articles published from January 1, 2000, to May 23, 2024;

(viii) Language (English and Spanish);

The following records have been excluded:

(i) Studies conducted on subjects with pathologies (diabetes, cancer, hepatic or renal diseases, *etc.*);

(ii) Case studies, case series, ecological studies, letters to the editor, reviews (narrative, scoping, systematic and meta-analyses) and consensus documents;

(iii) Studies which included participants aged <18 years old;

(iv) Studies focused on athletes;

(v) Studies where the consumption was evaluated through national and family budget surveys;

(vi) Studies in which the analysis of beer consumption was analysed in combination with other alcoholic beverages such as: beer + cider or beer + wine or beer + spirits.

2.3 Information sources

A structured search was conducted in four electronic databases: Medline (PubMed), SciELO, Web of Science (WOS) and SCOPUS between March 2024 and May 2024 to identify studies describing the association or effect of moderate beer consumption and dietary patterns and nutritional status parameters. No additional relevant articles or grey literature were searched.

2.4. Search strategy

The following search strategy was adapted according to each database and includes terms related to beer consumption and the different outcomes related with dietary patterns and nutritional status parameters, as well as a combination of these using the Medical Subject Headings (MeSH) index and Boolean operators: *("beer"[All Fields] OR "beer consumption"[All Fields] OR "moderate beer consumption"[All Fields] OR ("moderate alcohol consumption"[All Fields] AND "beer" [All Fields])) AND ("nutritional status"[All Fields] OR "nutritional quality"[All Fields] OR "health behaviours"[All Fields] OR ("diet"[MeSH Terms] OR "diet"[All Fields]) OR "dietary habits"[All Fields] OR "Mediterranean diet"[All Fields] OR "healthy diet"[All Fields] OR ("nutrients"[MeSH Terms] OR "nutrients"[All Fields]) OR "macronutrients"[All Fields] OR ("micronutrients"[All Fields] OR "micronutrients"[MeSH Terms]) OR ("vitamins"[MeSH Terms] OR "vitamins"[All Fields]) OR ("minerals"[MeSH Terms] OR "minerals"[All Fields]) OR ("antioxidants"[MEsH Terms] OR "antioxidants"[All Fields])).*

There were applied the filters of publication date: *From 2000/01/01 to 2024/05/23; type of study, species (humans), languages (English and Spanish).*

ESI 1† shows the exact search strategy considered in the different databases used in this systematic review and meta-analysis: Medline, SciELO, Web of Science and Scopus.

2.5 Selection process

After removing duplicates, each register was screened by two researchers (L. G. G.-R., L. M. B.) independently identified potential eligible registers for further review by examining the titles and abstracts according to the eligibility criteria. Differences in study selection were resolved by a third researcher (A. A.).

Full-text eligibility assessment was conducted by two reviewers (L. G. G.-R., L. M. B.) independently. Conflicts were resolved by a discussion among reviewers at the end of the second screening process.

2.6. Data collection process

Data from each report was first extracted independently by seven reviewers (R. M. O., A. M. L.-S., A. A. L. M. B., L. G. G.-R., V. L.-K. and M. C. L.-E.), then discussed by the reviewers, and eventually checked for correctness and clarity by two reviewers (L. G. G-R., L. M. B.). The collected data included the first author's name, year of publication, country where the study was conducted, study design, aim of the study, sample size, participants characteristics (sex and age range), eligibility criteria of the participants, intervention and control group treatment, duration, and amount in the case of interventional studies, method used to assess alcohol/beer consumption, categories established for comparison, dietary and biochemical outcomes related to nutritional status: (i) dietary parameters of the nutritional status: dietary patterns, diet quality indices (such as MEDAS, HEI…), food consumption (expressed in grams per day, servings per day, or frequency of consumption), energy intake, energy without alcohol, nutrient intake (expressed as grams per day or %TEI), protein intake, vegetal protein, carbohydrate, fibre, fat, saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), cholesterol, vitamins and minerals and (ii) biochemical parameters of the nutritional status: fatty acids, vitamins and minerals, among others (measured in serum, urine, or other biological samples), methods used to assess the selected outcomes, results related with beer consumption and abstainers, statistical adjustments and limitations of the studies. Results for each studied outcome were presented as mean differences between moderate beer drinkers and abstainers, as well as pre- and post-intervention (intra-group) differences and inter-group comparisons, where applicable.

The main or corresponding authors were contacted by e-mail to collect data that were not available in the article or to clarify aspects about the results that were not clear.

2.7 Study risk of bias assessment

The quality assessment for each study was assessed using the tool of the National Heart, Lung and Blood Institute (NHLBI)[24] (**https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools**). The NHLBI tool was selected because it provides tailored checklists for both observational and interventional studies and is widely used in nutritional epidemiology. Each tool consisted of 12 to 14 items: for cross-sectional studies included 14 criteria; for controlled interventional studies included 14 criteria and for pre- and post-interventional studies included 12 criteria. This quality tool assesses bias based on the research question, participants, recruitment and eligibility criteria, sample size, bias in the exposure of interest and outcome assessment, blinding of the process, randomization, attrition rate, and statistical analyses, and other aspects depending on the type of study. Two independent researchers (L. G. G. R. and M. C. L. E) assessed each article and inconsistencies were solved by involving a third researcher (A. A.).

Cross-sectional studies were rated as 'good' if the score was ≥11, 'fair' if the score ranged between 5 and 10, and 'poor' if the score was ≤4. Controlled interventional studies were rated as 'good' (A) if the final score was ≥10, 'fair' (B) if it ranged between 5 and 9, and 'poor' (C) if it was ≤4. Similarly, pre-post interventional studies were rated as 'good' (A) if the final score was >10, 'fair' (B) if it ranged between 5 and 10, and 'poor' (C) if it was ≤4.

2.8 Statistical analysis

The data extracted from interventional studies were insufficient for meta-analysis due to the limited number of relevant studies and the number of measured outcomes. Consequently, meta-analysis was performed exclusively on results from observational studies, while findings from interventional studies were addressed qualitatively.

For the meta-analysis, crude (unadjusted) mean values and standard deviations were used. When necessary, energy values reported in kilojoules were converted to kilocalories (1 kcal = 4.184 kJ), and macronutrient intakes reported in grams were converted to percentage of total energy intake (%TEI) using standard Atwater factors. In cases where studies reported standard errors (SE) instead of standard deviations (SD), SDs were calculated using the formula $SD = SE \times \sqrt{n}$.

The DerSimonian and Laird random effects method[25] was used to compute pooled estimates of standardized mean difference (SMD) and 95% confidence intervals (95% CIs) for the effect of moderate beer consumption *versus* abstainers on selected outcomes. Since studies with different units of measurement were included, the standardized mean difference (SMD) for the included studies was calculated using the Campbell Collaboration calculator. SMD values around 0.2 were considered weak effect, values around 0.5 were considered moderate effect, values around 0.8 were considered strong effect, and values larger than 1.0 were considered very strong effect. In addition, meta-analyses were performed for seven selected outcomes (diet quality indices, energy intake, %TEI protein, %TEI carbohydrates, %TEI SFA, %TEI MUFA, %TEI PUFA), using the raw values of mean differences (MD). The I^2 statistic, which ranges from 0% to 100%, was used to assess heterogeneity.[26] Based on I^2 values, heterogeneity was categorized as not important (0%–30%), moderate (30%–60%), substantial (60%–75%), or considerable (75%–100%). Additionally, for the evaluation of heterogeneity, the p values were considered (when $p < 0.05$, heterogeneity was found).

Sensitivity analysis (systematic reanalysis by removing studies one at a time) was performed to assess the robustness of the summary estimates.

Publication bias was assessed using Egger's regression asymmetry test.[27] A level <0.10 was used to determine whether publication bias might be present.

All statistical analyses were performed with STATA SE software, version 15 (StataCorp, College Station, Texas, USA).

3. Results

3.1 Literature search and study selection

The literature search yielded 1664 records. After excluding 165 duplicates, a total of 1499 records were evaluated, resulting in 121 reports identified as potential studies. After full-text review, 16 reports (15 independent samples) were included in the systematic review (qualitative synthesis), and 5 reports were included in the meta-analysis (Fig. 1).

3.2 Study characteristics

Tables 1 and 2 show the main characteristics of the reports included. All studies were published between 2001 and 2022. Six studies were conducted in Spain, four in the Netherlands, two in the Czech Republic, one in the United States, one in Germany, one in Italy and one in the United Kingdom. There were nine reports from observational studies.[28–36] These studies were focused on the analysis of beer consumption and its association with dietary patterns, diet quality, food consumption, nutrient intake and biochemical parameters of nutritional status. In addition, seven interventional studies were included, of which three were randomized controlled trials (one parallel group design[37] and two crossover design[38,39]), two were non-randomized controlled trials[40,41] and two were a pre-post interventional studies.[42,43] These studies focused on evaluating interventions involving the consumption of beer and their effects on food consumption, energy and nutrient intakes and on biochemical parameters of the nutritional status.

The sample sizes ranged from 11[39] to 33 185[28] participants per study, yielding a total sample of 48 129 participants. Eleven reports included both women and men in their samples (68.8%), while two studies included only women (12.5%), and three studies included only men (18.7%) (Tables 1 and 2).

In observational studies, only four studies[28,30,32,36] provided an explicit definition of 'moderate alcohol consumption', specifying the daily alcohol intake thresholds used to categorize consumption as moderate. The maximum amount considered within the definition of moderate consumption among these studies ranged from 10 to 24.9 g day^{-1} for women and from 20 to 40 g day^{-1} for men (Table 1). In contrast, five observational studies[29,31,33–35] only reported that they examined moderate consumption, without providing a specific definition of the intake considered as moderate. In interventional studies, the amount of alcohol in the form of beer considered as moderate by these authors varied from 11 to 30 g day^{-1} for women and from 24 to 40 g day^{-1} for men (Table 2).

3.3. Systematic review

The results of the studies included in the systematic review are displayed in Tables 3–8.

3.3.1. Studies on differences in dietary patterns between moderate beer consumers and abstainers. Table 3 summarizes findings from two studies[31,35] that reported data on moderate beer consumption and dietary patterns. McLernon *et al.*[31] found a significant association between different categories of beer consumption (including moderate) and dietary patterns in women (p = 0.001). Nevertheless, the highly uneven distribution of participants across consumption levels limits the robustness of these findings since the number of abstinent participants (n = 2935) far exceeded those with low (n = 212), moderate (n = 53), or high consumption (n = 18). Moreover, Sluik *et al.*[35] examined the relationship between dietary patterns and moderate beer consumption in both sexes. They found that beer drinkers exhibited higher scores for 'meat', 'snacks and drinks' and 'bread' and lower scores for 'salads', 'potatoes and sweets' and 'low-fat dairy and cereals' dietary patterns compared to abstainers. However, when the researchers adjusted for different confounding variables like age, sex, education, birth country, employment status, and prevalent diseases, moderate beer consumers (B) continued exhibiting higher scores for the 'meat' dietary pattern compared to abstainers (A) [B: 0.09 (0.07) *vs.* A: −0.22 (0.06); p < 0.05], but no significant differences were observed for the rest of the dietary patterns: 'snacks and drinks': [B: 0.01 (0.06) *vs.* A: 0.01 (0.06); p > 0.05], 'salads': [B: −0.15 (0.07) *vs.* A: −0.23 (0.06); p > 0.05], 'bread': [B: 0.07 (0.07) *vs.* A: 0.11 (0.07); p > 0.05], 'potatoes and sweets': [B: −0.07 (0.07) *vs.* A: −0.04 (0.06); p > 0.05], 'low-fat dairy and cereals': [B: 0.04 (0.07) *vs.* A: 0.05 (0.07); p > 0.05].

3.3.2. Studies on differences in diet quality indices between moderate beer consumers and abstainers. Table 4 summarizes findings from four studies that reported differences in diet quality between moderate beer drinkers and abstainers.[30,32,34,36] Of these, three studies[30,32,36] found no significant differences in diet quality between beer drinkers and abstainers. In contrast, Sluik *et al.*[34] observed that abstainers had a slightly higher diet quality than moderate beer drinkers. However, when researchers adjusted their results for multiple confounders, such as age, sex, body mass index (BMI), smoking status, educational level, physical activity, energy, total alcohol consumption, drinking frequency and weighted for demographic factors, seasons and day of the week, they observed that diet quality was similar between groups [61.7 (0.6) *vs.* 63.9 (0.04); p > 0.05].

3.3.3. Studies on differences in food consumption between moderate beer consumers and abstainers. Table 5 summarize findings from three observational studies[28,29,34] and from one interventional study[43] that reported data on the analysis of the differences in food consumption between moderate beer drinkers and abstainers. In this regard, Djoussé *et al.*[29] found no statistically significant differences in the consumption of fruit and vegetables. Conversely, the results of Sluik *et al.*[34] and Moreno-Llamas and De la Cruz-Sánchez[28] demonstrated some

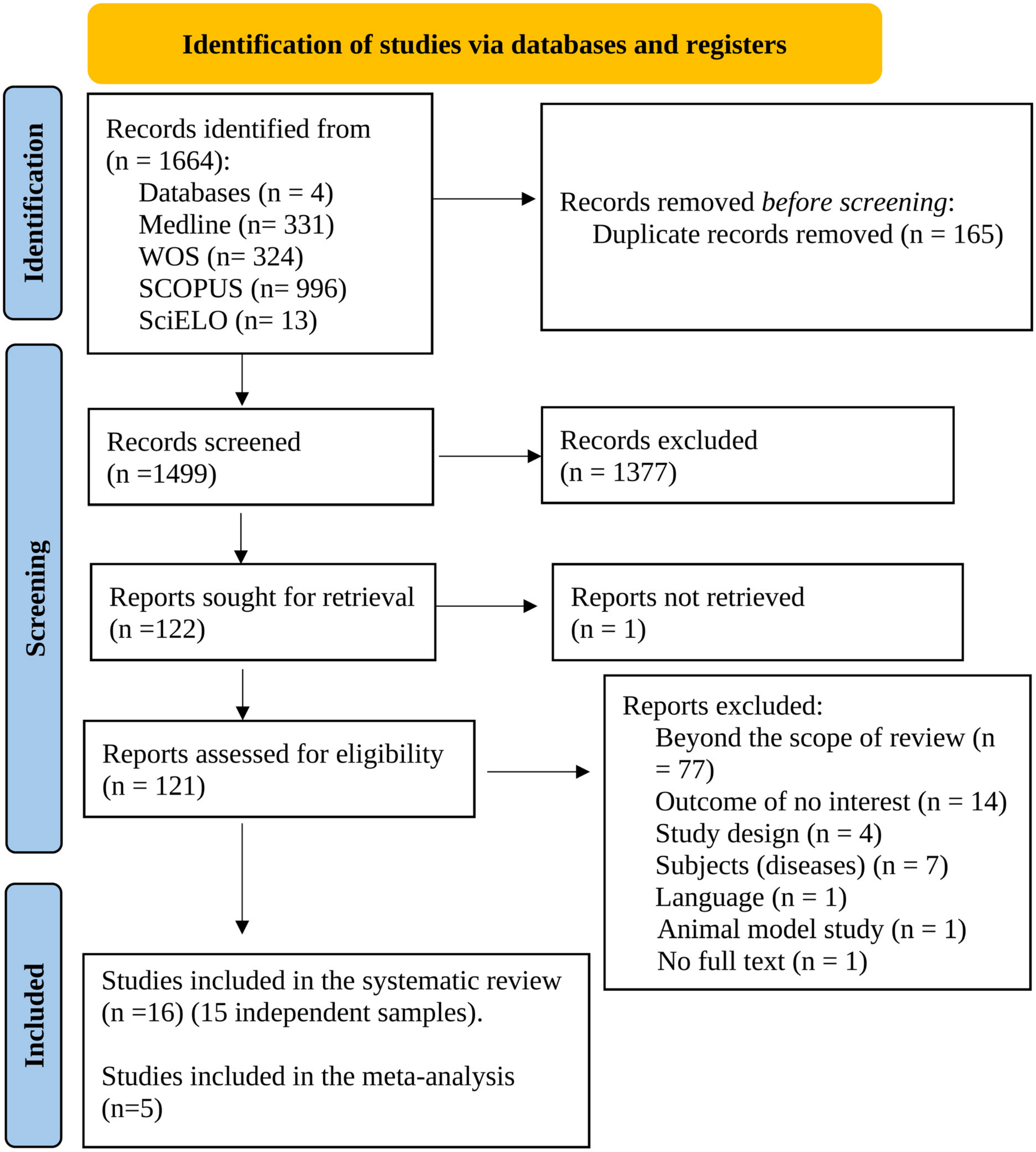

Fig. 1 Preferred reporting items for systematic reviews and meta-analyses PRISMA flow diagram of identification, screening, eligibility, and inclusion of studies.

differences in the consumption of certain food items. Specifically, Sluik *et al.*[34] showed beer drinkers consumed less fruit, yogurt, eggs, water, and tea, while eating more potatoes, tubers, milk, bread, pastries, meat, margarine, frying fats, soft drinks, coffee, sauces, seasonings, and snacks than abstainers. Nevertheless, after multiple adjustments (detailed previously), only the higher coffee consumption among moderate beer consumers compared to abstainers remained significant [B: 554 (21) *vs.* A: 440 (17) g day^{-1}; $p < 0.05$]. In addition, after adjustment new statistically significant differences were observed between moderate beer consumers and abstainers for butter [B: 1 (0) *vs.* A: 3 (0) g day^{-1}; $p < 0.05$], sugar and confectionary [B: 38 (2) *vs.* A: 49 (2) g day^{-1}; $p < 0.05$], and juices [B: 71 (10) *vs.* A: 110 (8) g day^{-1}; $p < 0.05$]. In addition, Moreno-Llamas and De la Cruz-Sánchez[28] found that the percentage of individuals who consume fruit (B: 61.3 *vs.* A: 72.3%; $p < 0.05$), vegetables (B: 42.9 *vs.* A: 45.2%; $p < 0.05$) and sweets (B: 26.0 *vs.* A: 28.2%; $p < 0.05$) once or more times per day was significantly lower among moderate beer consumers compared to abstainers. By contrast, the percentage of individuals who consume sweetened beverages

Table 1 Characteristics of observational studies included in the systematic review and/or meta-analysis

		Participants			Exposition				
Reference – country	Study design	Age	Sex[a]	Sample size	Moderate alcohol consumption thresholds[b]	Alcohol consumption[c] (Method)	Comparison category	Outcomes (Method)	Quality
Djoussé *et al.* (2004)[29] – USA	Cross-sectional	25–93 years	W/M	4510	N/A	B: 15.6 (16.4) g day^{-1} A: 0 (0) g day^{-1} (Questionnaire)	*Drink preference* B/Wn/S/Mx/A	Food consumption Nutrient intake (SQ-FFQ)	Fair
Maugeri *et al.* (2020)[30] – Czech Republic	Cross-sectional	25–64 years	W/M	1773	W: ≤10 g day^{-1} M: ≤20 g day^{-1}	N/A (FFQ)	*Beer consumption* L–M: W: ≤10 g alcohol per day M: ≤20 g alcohol per day H: W: ≤10 g alcohol per day M: ≤20 g alcohol per day A: 0 g alcohol per day *Drink preference* EB/B/EWn/Wn/A	Diet quality index (24-HR)	Fair
McLernon *et al.* (2012)[31] – UK	Cross-sectional	50–62 years	W	3218	N/A	4.7 (0.0–9.7) g day^{-1} (FFQ)	*Beer consumption* 0 g alcohol per day >0–5 g alcohol per day >5–10 g alcohol per day >10 g alcohol per day	Dietary patterns (FFQ)	Fair
Moreno-Llamas *et al.* (2023)[28] – Spain	Cross-sectional	>18 years	W/M	33 185	W: ≤12 g day^{-1} M: ≤24 g day^{-1}	N/A (Questionnaire)	*Beer consumption* B/HB/OB/ExB/A	Food consumption (FFQ)	Fair
Nova *et al.* (2018)[32] – Spain	Cross-sectional	55–85 years	W/M	240	W: <25 g day^{-1} M: <40 g day^{-1}	B: 12.5 (8.1) g day^{-1} A: 0.75 (1.2) g day^{-1} (FFQ)	*Drink preference* B/Mx/A	Diet-quality index (MEDAS)	Fair
O Mayer *et al.* (2001)[33] – Czech Republic	Cross-sectional	35–65 years	W/M	543	N/A	W/M: 13.2 (0.84) g day^{-1} (Questionnaire)	*Beer consumption* 0–4 g alcohol per day >4–14 g alcohol per day >14–28 g alcohol per day >28 g alcohol per day	Folate (Microparticle enzyme immunoassay)	Fair
Sluik *et al.* (2014)[34] – Netherlands	Cross-sectional	>18 years	W/M	2100	N/A	B: 20 (0–40) g day^{-1} A: 0 (0–0) g day^{-1} (Questionnaire)	*Drink preference* B/Wn/S/Mx/A	Diet-quality index (DHD) Food consumption (24-HR)	Fair
Sluik *et al.* (2016)[35] – Netherlands	Cross-sectional	20–77 years	W/M	2048	N/A	B: 11 (4–22) g day^{-1} A: 0 (0–0) g day^{-1} (FFQ)	*Drink preference* B/Wn/S/Mx/A	Dietary patterns (FFQ) Nutrient intake (FFQ)	Fair
Vicente-Castro *et al.* (2023)[36] – Spain	Cross-sectional	25–45 years	W M	247	W: 5–16 g day^{-1} M: 5–28 g day^{-1}	B: 10.9 (4.8) g day^{-1} (Questionnaire)	*Alcohol consumption* [d] L: 0.7–<5 g per day B: W: 5–16 g per day M: 5–28 g day^{-1} A: <0.7 g per day	Diet-quality index (MEDAS)	Fair

W/M, women/men; W, women; M, men; N/A, not available; B, moderate beer consumption; A, abstainers; Wn, wine; S, spirits; Mx, mixed consumption; SQ-FFQ, semi-quantitative food frequency questionnaire; FFQ, food frequency questionnaire; L–M, light to moderate drinker; 24HR, 24-hour record; H: heavy drinker; EB, exclusively beer; EWn, exclusively wine; HB, high beer consumption; OB, occasional beer consumption; ExB, ex-beer drinkers; MEDAS, Mediterranean Diet Adherence Screener; DHD, Dutch Healthy Diet; L, low. [a] W/M: results are reported for women and men together; W: results are reported for women separately; M: results are reported for men separately. [b] 'Moderate alcohol consumption' refers to the intake thresholds defined by the authors when specified. [c] Mean (standard deviation or range) when specified. [d] Alcohol consumption data is shown where beer as the preferred alcoholic beverage.

Table 2 Characteristics of interventional studies included in the systematic review and/or meta-analysis

		Participants			Intervention						
Reference – country	Study design	Age[a]	Sex[b]	Sample size	Group	Intervention	Beer amount[c]	Alcohol amount[c]	Duration	Outcomes (method)	Quality
Addolorato *et al.* (2008)[37] – Italy	RCT	28 (6) years*	M	40	B: 10	Beer	1000 mL day^{-1}; 4%	40 g day^{-1}	4 weeks	Alpha-tocopherol	Poor
					Wn: 10	Red wine	400 mL day^{-1}; 11%	40 g day^{-1}		(HPLC)	
					S: 10	Spirits	120 mL day^{-1}; 40%	40 g day^{-1}			
					A: 10	Control group	0 mL	0 g day^{-1}			
Beulens *et al.* (2005)[38] – Netherlands	CRCT	49–62 years W	W/M	20	B: 10	Beer	3 glasses per day W	30 g day^{-1} W	3 weeks ×2 (Wp: 1 weeks).	Vitamin B_6	Fair
		45–64 years M			AB: 10	Alcohol-free beer	4 glasses per day M	40 g day^{-1} M		Pyridoxal-5-phosphate	
							3 glasses per day W			Pyridoxal	
							4 glasses per day M			Folate Vitamin B_{12} (Immunoassay)	
Bleich *et al.* (2001)[40] – Germany	NRCT	28–44 years	M	60	B: 15	Beer	—	30 g day^{-1}	6 weeks	Vitamin B_6	Fair
					Wn: 15	Red wine	—	30 g day^{-1}		Folate	
					S: 15	Spirits	—	30 g day^{-1}		Vitamin B_{12}	
					A: 15	Control group	0 mL	0 g day^{-1}		(HPLC)	
Romeo *et al.* (2006)[42] – Spain	Pre-post intervention	34.9 (5.8) years*	W	22	B: 46	Beer	330 mL day^{-1}; 4.5% W	12 g day^{-1} W	4 weeks	Nutrient intake	Fair
			M	24	A: 46		660 mL day^{-1}; 4.5% M	24 g day^{-1} M		(7 day dietary record)	
Romeo *et al.* (2008)[43] – Spain	Pre-post intervention	35–50 years	W	27	B: 57	Beer	330 mL day^{-1} (4.5%) W	11 g day^{-1} W	4 weeks	Food consumption	Fair
			M	30	A: 57		660 mL day^{-1} (4.5%) M	24 g day^{-1} M		Nutrient intake (7 day dietary record)	
Trius-Soler *et al.* (2021)[14] – Spain	NRCT	49–70 years	W	31	B: 15	Beer	300 mL day^{-1}	14 g day^{-1}	48 weeks	Nutrient intake (SQ-FFQ)	Fair
					AB: 6	Alcohol-free beer	600 mL day^{-1}	N/A			
					A: 10	Control group	0 mL day^{-1}	0 g day^{-1}			
Van der Gaag *et al.* (2000)[39] – Netherlands	CRCT	44–59 years	M	11	B: 11	Beer	4 glasses	40 g day^{-1}	3 weeks (Wp: 0 weeks).	α-Tocopherol	Fair
					W: 11	Red wine	4 glasses	40 g day^{-1}		γ-Tocopherol	
					S: 11	Spirits	4 glasses	40 g day^{-1}		Vitamin C	
					A: 11	Control group	0 mL	0 g day^{-1}		Lutein Zeaxanthin β-Cryptoxanthin Lycopene α-Carotene β-Carotene (HPLC)	

RCT, randomised controlled trial; M, men; B, moderate beer intervention; Wn, wine; S, spirits; A, abstainers; HPLC, high performance liquid chromatography; CRCT, crossover randomised controlled trial; W, women; AB, alcohol-free beer; Wp, washout period; NRCT, non-randomised controlled trial; N/A, not available; SQ-FFQ, semi-quantitative food frequency questionnaire. [a] Age distribution range unless marked with an asterisk (*) where age is presented as mean and standard deviation. [b] W/M: results are reported for women and men together; W: results are reported for women separately; M: results are reported for men separately. [c] All interventions assessed 'moderate alcohol/beer consumption' according to the authors' criteria.

Table 3 Summary of observational studies included in the systematic review focused on characterization of dietary patterns that included beer or that analysed the differences on dietary patterns between moderate beer consumers and abstainers

Reference	Dietary patterns characteristics	Beer consumption	Results %, mean (SD)
McLernon *et al.* (2012)[31]	Low smoking, high fruit and vegetable intake and high physical activity (LS-HF/V-HP)	0 g alcohol per day	LS-HF/V-HPA (6.1%) *vs.* LS-LFV-LPA (7.9%) *vs.* HS-LFV (4.3%)
		>0–5 g alcohol per day	LS-HF/V-HPA (1.2%) *vs.* LS-LFV-LPA (1.2%) *vs.* HS-LFV (3.2%)
	Low smoking, low fruit and vegetable intake and low physical activity. (LS-LFV-LPA)	>5–10 g alcohol per day	LS-HF/V-HPA: (0.1%) *vs.* LS-LFV-LPAL (0.7%) *vs.* HS-LFV (0.7%)
		>10 g alcohol per day	LS-HF/V-HPA (92.6%) *vs.* LS-LFV-LPA (90.2%) *vs.* HS-LFV (91.9%)
	High smoking and low fruit and vegetable intake (HS-LFV).		$p = 0.001$ (Pearson's chi-square test)
Sluik *et al.* (2016)[35]	*Meat*	B	0.2 (1.0)[a]
	Meat and meat products, potatoes and fat	A	−0.25 (−3.9)[b]
	Snacks and drinks	B	0.2 (1.0)[a]
	Snacks, sauces, sugar, sweetened beverages and refined grains	A	0.13 (2.0)[b]
	Salads	B	−0.3 (1.0)[a]
	Vegetables, fats, sauces, fish, fruit and eggs	A	−0.24 (-3.8)[b]
	Bread	B	0.13 (1.0)[a]
	Whole grains, vegetable spreads, meat and meat products and potatoes	A	0.08 (1.3)[b]
	Potatoes and sweets	B	−0.18 (1.4)[a]
	Potatoes, sugar, fat, moderate-high-fat dairy products and refined bread	A	−0.06 (−0.9)[b]
	Low-fat dairy and cereals	B	−0.03 (1.0)[a]
	Whole grains and low-fat dairy products	A	0.07 (1.1)[b]

SD, standard deviation; B, moderate beer consumption; A, abstainers. [a,b]Different letters indicate statistically significant differences between moderate beer consumers and abstainers ($p < 0.05$).

Table 4 Summary of observational studies included in the systematic review focused on the analyse of the differences on diet quality scores between moderate beer consumers and abstainers or differences between categories of beer consumption

Reference	Diet quality index	Reference range	Group	Mean (SD)	%	*p*-Value
Maugeri *et al.* (2020)[30]	Diet score	Poor (P)	B	N/A	P 11.7%; I 86.3%; ID 2.0%	$p > 0.05^a$
		Intermediate (I)	A	N/A	P 14.9%; I 81.3%; ID 3.8%	
		Ideal diet (ID)				
Maugeri *et al.* (2020)[30]	Diet score	Poor (P)	L–M	N/A	P 12.0%; I 86.0%; ID 2.1%	$p > 0.05^b$
		Intermediate (I)	H	N/A	P 13.2%; I 84.1%; ID 2.7%	
		Ideal diet (ID)	A	N/A	P 14.1%; I 80.1%; ID 5.9%	
Nova *et al.* (2018)[32]	MEDAS	0–14 points	B	4.8 (1.3)[a]	—	—
			A	4.5 (1.4)[a]		
Sluik *et al.* (2014)[34]	DHD	0–100%	B	58.8 (11.8)[a]	—	—
			A	64.9 (10.1)[b]		
Vicente-Castro *et al.* (2023)[36]	MEDAS	0–14 points	B	M 7.3 (1.9)[a]	—	—
			A	M 7.1 (2.6)[a]		
			B	W 7.6 (1.9)[a]		
			A	W 7.7 (1.8)[a]		

SD, standard deviation; B, moderate beer consumption; A, abstainers; N/A, not available; L–M, light to moderate drinker; H, heavy; MEDAS, Mediterranean Diet Adherence Screener; DHD, Dutch Healthy Diet; M, men; W, women. [a,b]Different letters indicate statistically significant differences between moderate beer consumers and abstainers ($p < 0.05$). ^{a} *p*-Value derived by Pearson's chi-square test between B and A. ^{b} *p*-Value derived by Pearson's chi-square test using A as reference group.

(B: 10.2 *vs.* A: 8.2%; $p < 0.05$), fast food (B: 1.9 *vs.* A: 0.7%; $p < 0.05$) and snacks (B: 1.9 *vs.* A: 0.9%; $p < 0.05$) was slightly higher among moderate beer consumers than in abstainers. Alternatively, Romeo *et al.*[43] observed that after a daily consumption of 330 mL of beer for women and 660 mL for men over a period of four weeks, both sexes presented a significant decrease in the consumption of sauces and seasonings. Moreover, women decreased their consumption of dairy products and increased their consumption of pre-cooked foods.

3.3.4. Studies on differences in nutrients intake between moderate beer consumers and abstainers. Table 6 summarizes findings from the three observational studies[29,34,35] that reported differences in energy and nutrient intake between moderate beer drinkers and abstainers. Regarding energy intake, one of the three studies[29] found no significant differences between moderate beer consumers and abstainers, while the other two studies[34,35] found that energy intake was higher in moderate beer drinkers compared with abstainers even when including

Table 5 Summary of observational and interventional studies included in the systematic review focused on the analyse of the differences in food consumption (serving per day, g day^{-1} and food frequency of consumption) between moderate beer consumers and abstainers

Reference	Food group	Unit	%, Mean (SD)	
			B	A
Observational studies				
Djoussé *et al.* (2004)[29]	Fruits and vegetables	Serving per day	2.9 (1.6)[a]	3.8 (1.9)[a]
Moreno-Llamas *et al.* (2023)[28]	Fruit	Almost never or never	3.9[a]	2.3[b]
		Less than once per week	3.8[a]	2.4[b]
		Once or twice per week	10.6[a]	6.3[b]
		Three or more times per week, but not daily	20.5[a]	16.8[b]
		Once or more times per day	61.3[a]	72.3[b]
	Vegetables	Almost never or never	0.91[a]	1.4[b]
		Less than once per week	2.5[a]	2.3[a]
		Once or twice per week	12.1[a]	11.4[a]
		Three or more times per week, but not daily	41.7[a]	39.8[b]
		Once or more times per day	42.9[a]	45.2[b]
	Sweets	Almost never or never	16.0[a]	19.4[b]
		Less than once per week	16.3[a]	16.5[a]
		Once or twice per week	22.3[a]	18.5[b]
		Three or more times per week, but not daily	19.4[a]	17.4[b]
		Once or more times per day	26.0[a]	28.2[b]
	Sweetened beverages	Almost never or never	41.9[a]	58.1[b]
		Less than once per week	19.9[a]	15.0[b]
		Once or twice per week	17.6[a]	12.0[b]
		Three or more times per week, but not daily	10.7[a]	6.8[b]
		Once or more times per day	10.2[a]	8.2[b]
	Fast food	Almost never or never	34.5[a]	58.8[b]
		Less than once per week	30.4[a]	22.4[b]
		Once or twice per week	27.8[a]	14.7[b]
		Three or more times per week, but not daily	5.5[a]	3.4[b]
		Once or more times per day	1.9[a]	0.66[b]
	Snacks	Almost never or never	31.7[a]	55.1[b]
		Less than once per week	31.6[a]	26.0[b]
		Once or twice per week	27.5[a]	13.8[b]
		Three or more times per week, but not daily	7.3[a]	4.3[b]
		Once or more times per day	1.9[a]	0.90[b]
Sluik *et al.* (2014)[34]	Potatoes and tubers	g day^{-1}	115 (78.9)[a]	92 (72.1)[b]
	Vegetables	g day^{-1}	116 (78.9)[a]	124 (72.1)[a]
	Legumes	g day^{-1}	4 (19.7)[a]	4 (24)[a]
	Fruit	g day^{-1}	80 (118.3)[a]	110 (120.2)[b]
	Nuts and seeds	g day^{-1}	9 (19.7)[a]	7 (24)[a]
	Milk	g day^{-1}	215 (236.7)[a]	155 (216.4)[b]
	Yogurt	g day^{-1}	77 (138.1)[a]	103 (120.2)[b]
	Cheese	g day^{-1}	38 (39.4)[a]	32 (24.0)[a]
	Pasta and rice	g day^{-1}	48 (78.9)[a]	41 (72.1)[a]
	Breads	g day^{-1}	161 (59.2)[a]	133 (72.1)[b]
	Dough and pastry	g day^{-1}	9 (19.7)[a]	5 (24.0)[b]
	Meat	g day^{-1}	141 (788.9)[a]	105 (72.1)[b]
	Fish	g day^{-1}	16 (39.4)[a]	15 (24)[a]
	Eggs	g day^{-1}	11 (19.7)[a]	13 (24)[b]
	Vegetable oil	g day^{-1}	3 (0)[a]	3 (0)[a]
	Butter	g day^{-1}	2 (0)[a]	2 (0)[a]
	Margarine	g day^{-1}	23 (19.7)[a]	18 (24)[b]
	Deep frying fats	g day^{-1}	3 (0)[a]	1 (0)[b]
	Sugar and confectionary	g day^{-1}	44 (39.4)[a]	48 (48.1)[a]
	Cake and biscuits	g day^{-1}	44 (59.2)[a]	48 (48.1)[a]
	Juices	g day^{-1}	78 (177.5)[a]	107 (168.3)[a]
	Soft drinks	g day^{-1}	307 (374.7)[a]	301 (360.6)[b]
	Water	g day^{-1}	437 (631.1)[a]	620 (577)[b]
	Coffee	g day^{-1}	616 (414.2)[a]	404 (384.7)[b]
	Tea	g day^{-1}	137 (414.2)[a]	300 (384.7)[b]
	Soups and bouillons	g day^{-1}	63 (118.3)[a]	60 (96.2)[a]
	Sauces and seasonings	g day^{-1}	37 (39.4)[a]	29 (24.0)[b]
	Snacks	g day^{-1}	14 (19.7)[a]	9 (24.0)[b]

Food	Unit	Period	Reference Romeo *et al.* (2008)[43] Mean (SD) Women	Men
Interventional studies				
Cereals	g week^{-1}	T0	1316 (580)[a]	1672 (1037)[a]
		T1	1339 (624)[a]	1530 (661)[a]
Dairy products	g week^{-1}	T0	2632 (1027)[a]	2715 (1756)[a]
		T1	2203 (770.9)[b]	2446 (1027)[a]
Eggs	g week^{-1}	T0	213 (137)[a]	238 (157)[a]
		T1	199 (151)[a]	272 (129)[a]
Sugars	g week^{-1}	T0	117 (67.2)[a]	151 (127)[a]
		T1	132 (106)[a]	149 (111)[a]
Oils	g week^{-1}	T0	117 (58.7)[a]	98.3 (69.0)[a]
		T1	98.0 (51.4)[a]	93.8 (58.7)[a]
Vegetables	g week^{-1}	T0	1524 (658)[a]	1446 (736)[a]
		T1	1352 (626)[a]	1347 (571)[a]
Pulses	g week^{-1}	T0	105 (66.2)[a]	231 (219)[a]
		T1	146 (138)[a]	205 (182)[a]
Fruit	g week^{-1}	T0	1457 (828)[a]	162 (1089)[a]
		T1	1628 (901)[a]	1387 (1179)[a]
Meat	g week^{-1}	T0	875 (300)[a]	1196 (485)[a]
		T1	908 (342)[a]	1329 (645)[a]
Fish	g week^{-1}	T0	676 (307)[a]	594 (360)[a]
		T1	545 (342)[a]	528 (390)[a]
Sauces and seasonings	g week^{-1}	T0	3.64 (3.92)[a]	4.4 (4.62)[a]
		T1	2.1 (2.5)[b]	1.9 (2.16)[b]
Pre-cooked	g week^{-1}	T0	208 (176)[a]	340 (275)[a]
		T1	315 (237)[b]	344 (244)[a]
Appetisers	g week^{-1}	T0	61.9 (43.0)[a]	92.9 (87.9)[a]
		T1	157 (162)[a]	91.0 (64.6)[a]

SD, standard deviation; B, moderate beer consumers; A, abstainers; g week^{-1}, grams per week; T0, pre-intervention; T1, post-intervention. [a,b]Different letters indicate statistically significant differences between moderate beer consumers and abstainers or significant intragroup differences between T1 and T0 ($p < 0.05$).

and excluding energy from alcohol. Nonetheless, in the study of Sluik *et al.*[34] after adjusting the data for confounding variables (detailed previously) these differences were not maintained [B: 10 037 (150.6) kJ day^{-1} (2399 (36) kcal day^{-1}) *vs.* A: 9493 (121.3) kJ day^{-1} (2269 (29) kcal day^{-1}); $p > 0.05$]. Only two studies[29,34] reported data about the energy profile between moderate beer consumers and abstainers. Djoussé *et al.*[29] find no differences between moderate beer consumption and abstainers groups. Sluik *et al.*[34] observed that moderate beer consumers had a lower contribution to the TEI from protein (%TEI protein) and carbohydrates (%TEI carbohydrates) compared to abstainers. Nevertheless, when the results were adjusted by confounding variables (detailed previously) both differences were not maintained [%TEI proteins: B: 15.1 (0.2) *vs.* A: 15.7 (0.2); $p > 0.05$]; [% TEI carbohydrates: B: 43.7 (0.4) *vs.* A: 44.5 (0.3); $p > 0.05$]. Only one study[34] analysed the energy from total fat and sugar, found no statistically significant differences in neither of them.

Moreover, two studies[29,34] reported data on the contribution of fatty acids to the TEI. The findings of Djoussé *et al.*[29] indicated no statistically significant differences between the groups. Nevertheless, Sluik *et al.*[34] reported that the %TEI from SFA, MUFA and PUFA was lower in beer drinkers than in abstainers. Additionally, although not significantly, the %TEI from fat was also slightly lower in beer drinkers in this study. However, when the results were adjusted by confounding variables (detailed above) these differences were not maintained for any of the fatty acids: [%TEI SFA: B: 12.0 (0.0) *vs.* A: 13.5 (0.0); $p > 0.05$], [%TEI MUFA: B: 11.3 (0.0) *vs.* A: 12.3 (0.0); $p > 0.05$], [%TEI PUFA: B: 6.4 (0.0) *vs.* A: 7.1 (0.0); $p > 0.05$].

One of the two studies[34] that reported fibre intake[29,34] found differences between moderate beer drinkers and abstainers and, as with other nutrients, the differences disappeared when the data were adjusted by covariates (detailed previously) [B: 21 (0) *vs.* A: 21 (0) g day^{-1}; $p > 0.05$].

Regarding vitamins and minerals intakes, only one study[34] reported the analysis of the intake of these nutrients considering moderate beer consumption or abstention. Moderate beer consumers exhibited higher intakes of B-complex vitamins (B_1, B_2, B_6, B_9, B_{12}), vitamins E and D, and minerals such as calcium, iron, potassium, magnesium, selenium, and zinc. They also assessed the intake of vitamin A and vitamin C, finding no statistically significant differences between the comparison groups. In addition, when data were adjusted by confounding variables (detailed above) only the differences for iron intake were maintained [10.1 (0.2) *vs.* 11.1 (0.1) mg day^{-1}; $p < 0.05$]. Table 7 summarizes the results of two interventional

Table 6 Summary of observational studies included in the systematic review focused on the analyse of the differences in energy and nutrients intake between moderate beer consumers and abstainers

Reference	Group	Results									
		Energy (kJ day^{-1})	Energy (kcal day^{-1})	Proteins (% TEI)	Carbohydrates (% TEI)	Fats (% TEI)	SFA (%TEI)	MUFA (% TEI)	PUFA (% TEI)	Fibre (g day^{-1})	Sugar (% TEI)
Djoussé *et al.* (2004)[29]	B	8222 (2826)[a]	1965 (675)[a]	17.2 (3.8)[a]	48.6 (9.4)[a]	—	11.1 (3.1)[a]	11.8 (3.1)[a]	4.3 (1.3)[a]	16.5 (8.4)[a]	—
	A	7171 (2441)[a]	1714 (583)[a]	18.6 (3.9)[a]	53.4 (9.5)[a]		11.2 (3.2)[a]	11.8 (3.2)[a]	4.5 (1.4)[a]	19.2 (8.9)[a]	
Sluik *et al.* (2014)[34]	B	11221 (2972)[a]	2682 (710)[a]	14.8 (3.9)[a]	42.2 (7.9)[a]	34.1 (5.9)[a]	12.8 (6.6)[a]	12.1 (6.6)[a]	6.7 (0)[a]	23 (0)[a]	17.7 (8.8)[a]
	A	8799 (2716)[b]	2103 (649)[b]	16 (2.4)[b]	46 (7.2)[b]	35.2 (7.2)[a]	13.3 (10.3)[b]	12.4 (10.3)[b]	6.8 (0)[b]	20 (0)[b]	22.1 (9.1)[a]
Sluik *et al.* (2016)[35]	B	9581 (2688)[a]	2290 (642)[a]	—	—	—	—	—	—	—	—
	A	7996 (2636)[b]	1911 (630)[b]								

Reference	Group	Results								
		Vitamin B_1 (mg day^{-1})	Vitamin B_2 (mg day^{-1})	Vitamin B_6 (mg day^{-1})	Vitamin B_9 (µg day^{-1})	Vitamin B_{12} (µg day^{-1})	Vitamin C (mg day^{-1})	Vitamin A (µg day^{-1})	Vitamin E (mg day^{-1})	Vitamin D (µg day^{-1})
Sluik *et al.* (2014)[34]	B	1.4 (0)[a]	1.9 (0)[a]	2.4 (2)[a]	302 (138.1)[a]	5.4 (3.9)[a]	91 (59.2)[a]	1092 (1045)[a]	14.9 (7.9)[a]	4 (2)[a]
	A	1.2 (0)[b]	1.6 (0)[b]	2 (0)[b]	261 (120.2)[b]	4.5 (2.4)[b]	98 (48.1)[a]	1018 (961.7)[a]	13.1 (7.2)[b]	3.6 (2.4)[b]

Reference	Group	Results					
		Calcium (mg day^{-1})	Iron (mg day^{-1})	Potassium (mg day^{-1})	Magnesium (mg day^{-1})	Selenium (µg day^{-1})	Zinc (mg day^{-1})
Sluik *et al.* (2014)[34]	B	1140 (473.4)[a]	11.4 (3.9)[a]	3988 (1104)[a]	401 (118.3)[a]	53 (19.7)[a]	12.3 (3.9)[a]
	A	1044 (432.7)[b]	10.3 (2.4)[b]	3279 (1009)[b]	323 (96.2)[b]	46 (24)[b]	10.4 (2.4)[b]

Data are presented as mean (SD: standard deviation). B, moderate beer consumers; A, abstainers; kJ, kilojoules; kcal, kilocalories; %TEI: total energy intake percentage; SFA, saturated fat acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids, g day^{-1}, grams per day; mg day^{-1}, milligram per day; µg day^{-1}, microgram per day. [a,b]Different letters indicate statistically significant differences between moderate beer consumers and abstainers (p < 0.05).

Table 7 Summary of interventional studies included in the systematic review focused on the analyse of the effect of beer consumption on energy and nutrients intake

			Reference		
			Romeo *et al.* (2008)[43]		
			Romeo *et al.* (2006)[42]		
Intake	Unit	Period	Women[a]	Men[a]	Trius-Soler *et al.* (2021)[41] Women[b]
Energy	kJ day^{-1}	T0	7431 (1715)[a]	9414 (3188)[a]	10 874 (8999, 13 129)[a]
		T1	7895 (1992)[a]	9648 (2075)[a]	10 368 (8142, 15 347)[a]
Energy	kcal day^{-1}	T0	1776 (410)[a]	2250 (762)[a]	2599 (2127, 3138)[a]
		T1	1887 (476)[a]	2306 (496)[a]	2478 (1946, 3668)[a]
Protein	%TEI	T0	17.9 (14.0)[a]	18.3 (17.5)[a]	19.2 (17.4, 21.8)[a]
		T1	16.7 (12.9)[a]	17.3 (16.9)[a]	18.2 (15.0, 20.5)[a]
Carbohydrate	%TEI	T0	47.7 (61.1)[a]	49.4 (58.8)[a]	33.5 (29.2, 38.9)[a]
		T1	47.9 (55.7)[a]	45.6 (61.5)[a]	30.2 (26.6, 36.9)[b]
Fats	%TEI	T0	36.1 (42.1)[a]	35.2 (38.4)[a]	47.3 (37.4, 50.2)[a]
		T1	34.1 (43.7)[a]	34 (39.7)[a]	47.2 (41.5, 51.9)[a]
Fibre	g day^{-1}	T0	14.7 (4.1)[a]	20.2 (11.7)[a]	36.6 (29.7, 41.0)[a]
		T1	16.3 (6.4)[a]	18.4 (8.0)[a]	33.5 (22.5, 45.6)[a]
Sugar	%TEI	T0	—	—	14.6 (11.3, 16.9)[a]
		T1			14.8 (10.7, 18.0)[a]
SFA	%TEI	T0	12.3 (14.9)[a]	11.7 (14.9)[a]	12.7 (10.9, 14.5)[a]
		T1	11.5 (15.1)[a]	11.3 (15.1)[a]	12.1 (11.3, 13.1)[a]
MUFA	%TEI	T0	13.9 (17.6)[a]	12.9 (13.9)[a]	23.3 (16.5, 26.8)[a]
		T1	13.2 (18.5)[a]	12.4 (15)[a]	23.9 (19.2, 27.9)[a]
PUFA	%TEI	T0	5.2 (7.1)[a]	5.1 (7)[a]	6.6 (6.0, 8.4)[a]
		T1	4.8 (9.2)[a]	5 (8.9)[a]	7.2 (5.9, 7.9)[a]
Cholesterol	mg day^{-1}	T0	307 (107)[a]	364 (130)[a]	—
		T1	300 (160)[a]	397 (119)[a]	
Calcium	mg day^{-1}	T0	870 (190)[a]	979 (425)[a]	1199 (935, 1552)[a]
		T1	820 (191)[a]	920 (284)[a]	1108 (810, 1543)[a]
Iron	mg day^{-1}	T0	11.2 (2.1)[a]	14.7 (5.1)[a]	—
		T1	11.8 (3.2)[a]	13.9 (3.5)[a]	
Iodine	μg day^{-1}	T0	327 (148)[a]	296 (151)[a]	—
		T1	281 (135)[b]	303 (148)[a]	
Magnesium	mg day^{-1}	T0	258 (48.1)[a]	306 (116)[a]	—
		T1	279 (70.6)[a]	322 (62.9)[a]	
Zinc	mg day^{-1}	T0	8.5 (1.9)[a]	11.9 (4.5)[a]	—
		T1	9.0 (2.3)[a]	11.9 (4.0)[a]	
Sodium	mg day^{-1}	T0	2825 (1240)[a]	3514 (1576)[a]	—
		T1	2595 (696)[a]	3143 (1244)[a]	
Potassium	mg day^{-1}	T0	2650 (480)[a]	3066 (968)[a]	—
		T1	2678 (607)[a]	3124 (724)[a]	
Phosphorus	mg day^{-1}	T0	1089 (202)[a]	1353 (547)[a]	—
		T1	1144 (225)[a]	1351 (271)[a]	
Selenium	μg day^{-1}	T0	42.5 (18.2)[a]	59.3 (30.0)[a]	—
		T1	46.0 (25.9)[a]	53.6 (22.7)[a]	
Vitamin B_1	mg day^{-1}	T0	1.0 (0.22)[a]	1.31 (0.50)[a]	—
		T1	1.11 (0.30)[a]	1.31 (0.33)[a]	
Vitamin B_2	mg day^{-1}	T0	1.37 (0.27)[a]	1.64 (0.62)[a]	—
		T1	1.43 (0.25)[a]	1.91 (0.46)[b]	
Eq. Niacin	mg day^{-1}	T0	25.17 (4.5)[a]	30.01 (8.13)[a]	—
		T1	26.77 (4.9)[a]	34.78 (6.26)[b]	
Vitamin B_6	mg day^{-1}	T0	1.24 (0.32)[a]	1.53 (0.63)[a]	—
		T1	1.47 (0.34)[b]	1.80 (0.37)[b]	
Vitamin B_9	μg day^{-1}	T0	139 (39.8)[a]	153 (68.7)[a]	—
		T1	168 (56.3)[b]	192 (46.7)[b]	
Vitamin B_{12}	μg day^{-1}	T0	3.87 (1.5)[a]	6.00 (2.77)[a]	—
		T1	5.58 (2.8)[b]	6.93 (3.6)[a]	
Vitamin C	mg day^{-1}	T0	76.5 (38.6)[a]	65.7 (28.4)[a]	—
		T1	79.3 (38.0)[a]	61.7 (27.1)[a]	
Vitamin A: Eq. Retinol	μg day^{-1}	T0	614 (224)[a]	901 (550)[a]	—
		T1	788 (486)[b]	868 (547)[a]	

Table 7 *(Contd.)*

Intake	Unit	Period	Reference: Romeo *et al.* (2008)[43] / Romeo *et al.* (2006)[42] Women[a]	Men[a]	Trius-Soler *et al.* (2021)[41] Women[b]
Retinol	μg day^{-1}	T0	286 (223)[a]	476 (478)[a]	—
		T1	408 (463)[a]	498 (533)[a]	
Carotenoids	μg day^{-1}	T0	1984 (1161)[a]	1719 (1420)[a]	—
		T1	2322 (1640)[a]	1805 (1212)[a]	
Vitamin D	μg day^{-1}	T0	3.88 (1.9)[a]	3.70 (3.5)[a]	6.4 (4.9, 8.3)[a]
		T1	3.80 (4.3)[a]	4.38 (1.9)[a]	5.8 (5.3, 7.4)[a]
Vitamin E	mg day^{-1}	T0	4.70 (1.9)[a]	4.87 (2.1)[a]	
		T1	4.75 (2.9)[a]	4.60 (1.4)[a]	
Polyphenols	mg day^{-1}	T0	—	—	753 (487, 853)[a]
		T1			844 (681, 973)[a]

kJ, kilojoules; T0, pre-intervention; T1, post-intervention; kcal, kilocalories; %TEI, total energy intake percentage; g day^{-1}, grams per day; SFA, saturated fat acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; μg day^{-1}, milligram per day; mg day^{-1}, microgram per day. [a,b]Different letters indicate statistically significant intragroup differences between T1 and T0 ($p < 0.05$). [a] Mean (SD: standard deviation) [b] Median (IQR: interquartile range).

studies[41–43] investigating the effect of beer consumption on nutrient intakes. Romeo *et al.*[42,43] reported that, after the consumption of 330 mL of beer per day for women and 660 mL per day for men over a period of 4 weeks, women showed an increased intake of vitamins A, B_6, B_9 and B_{12}, while men exhibited an increased intake of vitamins B_2, B_3, B_6, and B_9. Conversely, no significant differences were observed in the intake of energy and the remaining nutrients studied, except for a significant decrease in iodine intake. Trius-Soler *et al.*[41] observed only a significant decrease in the intake of energy from carbohydrates in women, with no significant differences in the intake of energy and other nutrients, after consuming 300 mL of beer daily over a period of 48 weeks.

3.3.5. Studies on differences in nutrition status biochemical parameters between moderate beer consumers and abstainers. Five studies–one observational[33] and four interventional[37–40] –analysed differences in biochemical parameters of nutritional status between moderate beer consumers and abstainers[33,37–40] (Table 8). No consistent trends were identified across studies, and heterogeneity in study design, beer dose, intervention duration, and analytical methods limit comparability. In addition, many parameters were assessed in single studies only, precluding the possibility of meta-analysis. Only serum α-tocopherol[37,39] and B vitamins[33,38,40] were analysed in more than one study, yet findings were inconsistent across them. All other biomarkers, including γ-tocopherol, vitamin C and carotenoids such as lutein, zeaxanthin, β-cryptoxanthin, lycopene, α-carotene, β-carotene and β-cryptoxanthin, were each examined in a single trial only,[39] making it impossible to evaluate consistency or trends.

3.4 Quality assessment

According to the assessment using the tool for quality assessment of the National Heart, Lung and Blood Institute (NIH),[24] the studies evaluated were generally rated as fair quality (93.8%) (Tables 1, 2 and ESI 2†). This has been mainly due to the own limitations of the type of studies design (cross-sectional), the robustness of methodological rigor, and inadequate control of confounding covariates, which may have introduced bias and weakened the validity of the reported associations.

3.5 Meta-analysis

The results of the meta-analysis are shown in Fig. 2. In this study, it was only possible to conduct a meta-analysis of data from observational studies, as insufficient information was available on the study variables from interventional studies. This quantitative analysis included five observational studies with a total of 9145 participants in which differences in various dietary parameters were assessed between moderate beer consumers and abstainers.

The analysis of diet quality measured with different diet quality indices showed that the pooled SMD was −0.10 (95% CI −0.57, 0.37), indicating no significant difference in diet quality scores between moderate beer consumers and abstainers with considerable heterogeneity ($I^2 = 84.6\%$; $p < 0.001$).

In relation to energy intake, the pooled SMD was 0.62 (95% CI 0.33, 0.91), suggesting that moderate beer consumers have significantly higher energy intake compared to abstainers [MD: 925.5 kJ day^{-1} (95% CI 441.4, 1414.9); 221.2 kcal day^{-1} (95% CI 105.5, 338.9)], showing considerable heterogeneity ($I^2 = 91.8\%$; $p < 0.001$). Regarding the intake of macronutrients, expressed as their contribution to the %TEI, it was observed that the pooled SMD for energy derived from protein and carbohydrate intake was −0.37 (95% CI −0.46, −0.29) ($I^2 = 0\%$; $p = 0.765$) and −0.51 (95% CI −0.59, −0.42) ($I^2 = 0\%$; $p = 0.994$), respectively, indicating that moderate beer consumers had a lower protein and carbohydrate intake [MD: −11.1 (95% CI −13.1, −9.1)] and [MD: −23.8 (95% CI −29.2, −18.3)], respectively in comparison with abstainers.

Table 8 Summary of observational and interventional studies included in the systematic review focused on the analyse of the effect of beer consumption (moderate beer consumers *vs.* abstainers and alcoholic beer consumption *vs.* alcohol-free beer) on biochemical parameters of the nutritional status

Parameter	Unit	Reference O Mayer *et al.* (2001)[33] Main result
Observational studies		
Vitamin B_9	ng mL^{-1}	J-shaped trend (↑ folate at 0–4 g per day per alcohol from beer (≈6.2 ng mL^{-1}) and >28 g per day per alcohol from beer (≈7.4 mg mL^{-1})); in comparison to the remaining categories (5.9 and 6.0 ng mL^{-1} approximately); $p < 0.01$

		Reference															
		Addolorato *et al.* (2008)[37]				Beulens *et al.* (2005)[38]				Bleich *et al.* (2001)[40]				Van der Gaag *et al.* (2000)[39]			
Parameter	Unit		T0	T1	%[a]		T0	T1	%[a]		T0	T1	%[a]		T0	T1	%[a]
Interventional studies																	
α-Tocopherol	μmol l^{-1}	B	10.3 (1.1)[a]	8.83 (1.3)[b]	−14.5		—	—	—		—	—	—	B	N/A	13.0 (2.8)	NS
		A	9.74 (1.1)[a]	9.72 (1.5)[a]	−0.2									A	N/A	12.5 (3.1)	NS
γ-Tocopherol	μmol l^{-1}		—	—	—		—	—	—		—	—	—	B	N/A	1.2 (0.37)	NS
														A	N/A	1.2 (0.52)	NS
Vitamin B_6	μg l^{-1}		—	—	—	B	N/A	N/A	+[b]	B	14.3 (6.2)[a]	13.8 (4.7)[a]	N/A	—	N/A	—	—
						AB	N/A	N/A	−[b]	A	11.3 (4.2)[a]	9.8 (3.1)[a]	N/A		N/A		
PLP	μg l^{-1}		—	—	—	B	N/A	N/A	+11[b]					—	N/A	—	—
						AB	N/A	N/A	−34[b]						N/A		
Pyridoxal	μg l^{-1}		—	—	—	B	N/A[a]	N/A[a]	NS					—	N/A	—	—
						AB	N/A[a]	N/A[a]	NS						N/A		
Vitamin B_9	ng mL^{-1}		—	—	—	B	N/A[a]	N/A[a]	NS	B	9.7 (3.3)[a]	8.9 (4.1)[a]	N/A	—	N/A	—	—
						AB	N/A[a]	N/A[a]	NS	A	12.3 (4.8)[a]	11.5 (3.9)[a]	N/A		N/A		
Vitamin B_{12}	pg mL^{-1}		—	—	—	B	N/A[a]	327 (22.2)[a]	N/A[b]	B	428 (118)[a]	479 (77)[a]	N/A	—	N/A	—	—
						AB	N/A[a]	382 (23.7)[a]	N/A[b]	A	512 (198)[a]	578 (112)[a]	N/A		N/A		
Vitamin C	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	65.5 (15.4)	−15[b]
														A	N/A	77.0 (15.0)	N/A
Lutein	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	0.184 (0.088)	NS
														A	N/A	0.183 (0.074)	NS
Zeaxanthin	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	0.019 (0.012)	NS
														A	N/A	0.019 (0.008)	NS
β-Cryptoxanthin	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	0.061 (0.023)	NS
														A	N/A	0.059 (0.026)	NS
Lycopene	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	0.154 (0.052)	NS
														A	N/A	0.151 (0.069)	NS
α-Carotene	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	0.035 (0.016)	NS
														A	N/A	0.037 (0.018)	NS
β-Carotene	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	0.119 (0.041)	−11[b]
														A	N/A	0.134 (0.048)	N/A
β-Cryptoxanthin	μmol l^{-1}		—	—	—		—	—	—	—	—	—	—	B	N/A	0.061 (0.023)	NS
														A	N/A	0.059 (0.026)	NS

Data are presented as mean (SD: standard deviation). μmol l^{-1}, micromoles per litre; B, moderate beer consumption; T0, pre-intervention; T1, post-intervention N/A, non-available; NS: non-significant; A, abstainers; μg l^{-1}, microgram per litre; AB: alcohol-free beer; PLP: pyridoxal-5-phosphate; pg mL^{-1}, picogram per millilitre. [a,b]Different letters indicate significant intragroup differences between T1 and T0 ($p < 0.05$). [a] Percentage of change between T1 and T0. [b] Statistically significant intergroup differences in the percentage of variation between beer and abstainers' groups ($p < 0.05$).

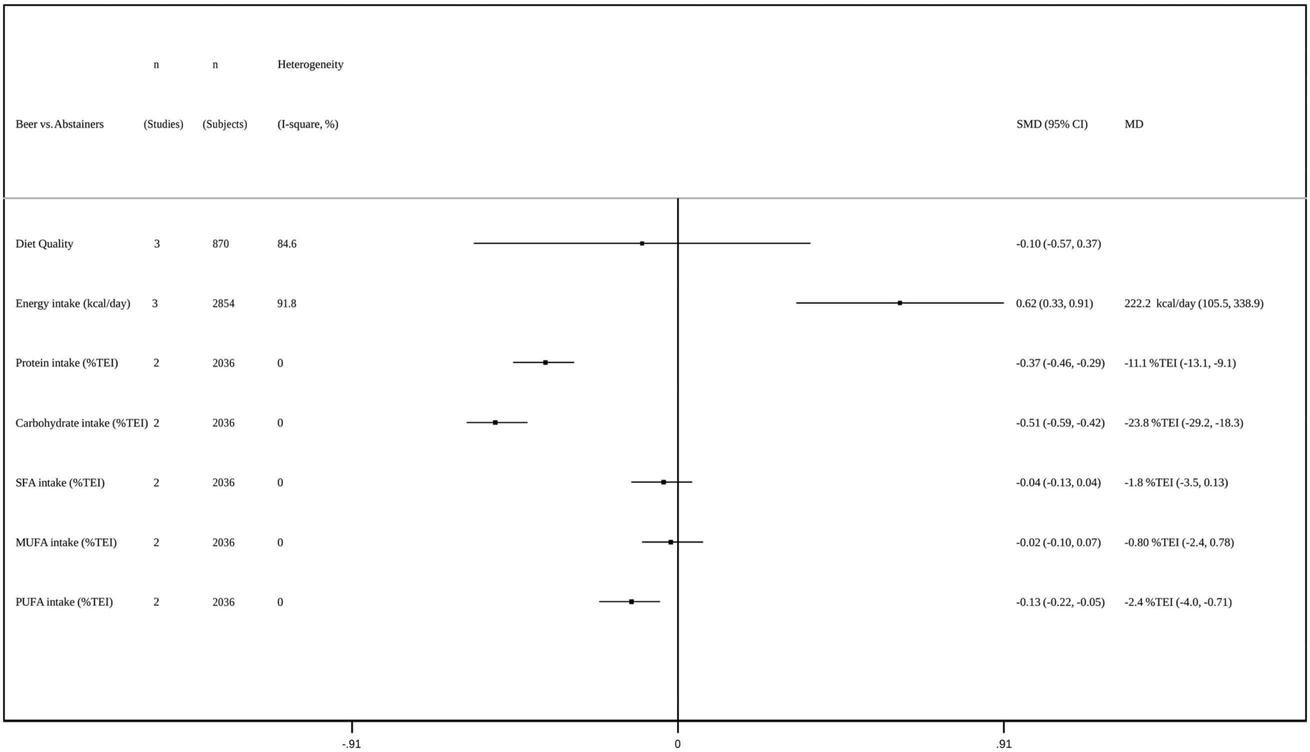

Fig. 2 Summary of pooled standardised mean differences (SMDs) with 95% confidence intervals (CIs) from observational studies assessing differences between moderate beer consumers and abstainers in diet quality indices and energy and nutrient intakes. %TEI: percentage from Total Energy Intake; CI: Confidence Interval; MD: Mean Difference; MUFA: Monounsaturated Fatty Acids; PUFA: Polyunsaturated Fatty Acids; SFA: Saturated Fatty Acids; SMD: Standardized Mean Difference.

Analysing the contribution of SFA, MUFA and PUFA to the TEI, no significant differences were observed between the comparison groups of study for SFA [SMD: −0.04 (95% CI −0.13, 0.04)] (I^2 = 0%; p = 0.785) and MUFA [SMD: −0.02 (95% CI −0.10, 0.07)] (I^2 = 0%; p = 0.705). For PUFA, the results [SMD: −0.13 (95% CI −0.22, −0.05)] (I^2 = 0%; p = 0.483) indicated a lower intake among moderate beer consumers [MD: −2.4%E (95% CI −4.0, −0.71)] than in abstainers.

The pooled SMD estimate for the effect of moderate beer consumption *versus* abstainers on selected outcomes was not significantly modified (in magnitude or direction) when data from individual studies were removed from the analysis one at a time.

Finally, evidence of publication bias was found by Egger's test for diet quality (p = 0.066).

4. Discussion

This systematic review and meta-analysis aimed to analyse the most recent evidence on moderate beer consumption and its potential impact on dietary and biochemical parameters of nutritional status. Specifically, it compared these parameters between moderate beer consumers and abstainers. This area has not been extensively explored in previous research.

Our findings suggest the presence of slight differences in dietary patterns, food consumption, energy intake, and the intake of some nutrients between moderate beer drinkers and abstainers. Conversely, according to the results from the meta-analysis, overall diet quality appeared to be similar for both groups.

However, these findings should be interpreted with caution due to the considerable heterogeneity and the fair quality, which could be largely attributable to a lack of robustness and uncontrolled confounding variables.

Based on the limited and inconsistent evidence available, the effects of moderate beer consumption on biochemical markers of nutritional status, remain uncertain.

In addition, the definitions of moderate beer consumption applied in the included studies do not fully reflect current low-risk drinking guidelines, which may limit the comparability and interpretation of the findings.

Several studies suggest that dietary habits are associated with the type of alcoholic beverage consumed. Health implications may be more closely associated with dietary patterns accompanying the consumption of these beverages.[20,44–46]

Beer consumption has been associated with both healthier and less healthy dietary patterns. On the one hand, beer consumption has been linked to healthier dietary choices.[5] On the other hand, beer preference has also been associated with less healthy dietary habits, specifically with lower adherence to dietary guidelines for fruit, vegetables, and animal-based foods such as fish, meat, and eggs, compared to individuals with no specific alcohol beverage preference or those who prefer wine.[20,45–47] In contrast, one study found,[48] no significant association between alcoholic beverage preference and adherence to the Mediterranean dietary pattern. Nonetheless, it is important to note that not all these studies consistently considered moderate alcohol or beer consumption in their analysis.

Conflicting findings were also observed in the present review. One observational study showed that moderate beer drinkers exhibited a dietary pattern more characterized by higher consumption of meat, meat products, potatoes and fats, compared to abstainers. When analysing food consumption individually, one study found no significant differences between moderate beer drinkers and abstainers. However, two observational studies reported some slightly conflicting findings regarding specific foods choices. Moderate beer consumers were observed to drink more coffee. In one study, they also tended to prefer less processed or energy-dense foods, such as butter, juices, sugar and confectionary in comparison with abstainers. Conversely, in other study, beer drinkers were found to consume fruit, vegetables and sweets less frequently during the day. Instead, they had higher consumption of sweetened beverages, fast food and snacks. However, it should be noted that in some cases, the frequency, although statistically significant, was very low in both groups (*e.g.* fast food and snacks).

An interventional study also examined short-term changes in food consumption following moderate beer intake. After one month of moderate beer consumption, a significant decrease in the consumption of sauces and seasonings was observed in both sexes. Moreover, women also decreased their consumption of dairy products and increased their consumption of pre-cooked foods.

In this regard, the available data does not provide sufficient scientific support to associate moderate beer consumption with the adoption of a specific dietary pattern or a particular preference for certain foods as has been previously suggested.

Some studies have also reported contradictory results in relation to diet quality between moderate beer drinkers, individuals who drink other alcoholic beverages, and abstainers.[7,28,49] The present meta-analysis from observational studies indicated that the overall diet quality of moderate beer consumers might be comparable to that of abstainers. In both cases, the quality of the diet might improve even as it deviates from the theoretical ideal of some diet quality indices such as the Mediterranean Diet Adherence Screener (MEDAS), Dutch Healthy Diet (DHD) or Diet score.

Although some studies have reported associations between moderate beer consumption and certain dietary patterns or food, groups, the available evidence does not support a consistent or substantial impact on overall diet quality. In this regard, overall diet quality is determined by the totality of foods consumed over time, rather than by a few isolated food choices.[50]

While excessive consumption of certain foods (*e.g.*, those high amounts of sugars, saturated fat, or salt) can be detrimental, it is the overall balance of diet that holds the greatest significance. Diet quality indices take into account factors such as diversity and the balance between different food groups and nutrients.[51] This means that, in some cases, an occasional excess of one specific food may not significantly impact on the overall index. Consistent consumption of essential nutrients is more important than sporadic dietary choices, as these can be compensated for by a regular intake of foods with high nutritional value.

In summary, occasional consumption of some specific foods does not necessarily alter the diet quality index if the rest of the dietary habits are adequate and balanced.

However, given the considerable statistical heterogeneity observed across the studies included in our meta-analysis, these results should be interpreted with caution. This variability may reflect underlying differences in study populations, methodologies, or confounding factors that could influence the observed associations. This variability may reflect underlying differences in study populations, methodologies, or confounding factors that could influence the observed associations.

Different authors have described that moderate alcohol consumption can contribute to a positive energy balance by providing a source of energy (approximately 43 kilocalories per 100 mL of beer) and stimulating appetite. This effect may be driven by several mechanisms, including the activation of gamma-aminobutyric acid (GABA) receptors and releasing opioids, the reduction of serotonin response which suppresses hunger, and the inadequate compensation of short-term satiety mechanisms for the energy provided by alcohol, making overconsumption of energy more likely.[19,21,52–54]

The present meta-analysis of three observational studies indicates that moderate beer consumers exhibited a higher energy intake than abstainers. Nevertheless, considerable statistical heterogeneity was also evident for this parameter. Therefore, these results warrant cautious interpretation. Additionally, mixed results were observed based on the results from the qualitative analysis. Specifically, one of the studies indicated that after adjusting for potential confounding factors such as age, sex, BMI, and physical activity, these differences were no longer statistically significant.[34] This could reflect the influence of individual characteristics and lifestyle factors on energy intake. Furthermore, an interventional study with standardized beer consumption (300–330 mL day^{-1} for women and 660 mL day^{-1} for men) found no significant differences in energy intake between beer drinkers and abstainers after 48 weeks. These findings suggest that moderate beer consumption might not inherently have a negative effect on energy intake, and its potential impact could depend on the overall dietary balance.

In addition, some studies have reported that the consumption of beer could contribute to overall intake of some nutrients, as it contains vitamins (*e.g.*, folate, choline), minerals (*e.g.*, magnesium, potassium, calcium), and bioactive compounds like phenolics (*e.g.*, ferulic acid, xanthohumol, catechins) derived from malt and hops.[7,9,15]

In this regard, the findings of our meta-analysis of two observational studies showed that moderate beer drinkers had lower energy intake from protein, carbohydrate and PUFA compared with abstainers. Conversely, no significant differences were found between groups in SFA and MUFA intake.

Regarding proteins, although this lower intake may initially seem concerning, it is important to note that in most developed countries, protein intake often exceeds recommendations, which can pose potential health risks.[55] In fact, in these studies, the mean protein intake for both moderate beer consumers and abstainers falls within the Dietary Reference Intakes (DRIs)[56] recommended range of 10–35% of TEI, suggesting no immediate risk from excess or deficiency.

For carbohydrates and PUFA, there was some variability in meeting the DRIs. One study met the DRIs[56] for carbohydrates (45–65% of TEI), while the other reported a mean intake slightly below this range. A similar pattern was observed for PUFA intake, where only one of the studies fell within the DRIs[57] range of 6–11% of TEI.

In the only study that identified differences between moderate beer consumers and abstainers in these parameters, it was observed that, after adjusting for potential confounding factors such as age, sex, BMI, and physical activity, no statistically significant differences in protein, carbohydrates, or PUFA intake remained between the two groups.[34] These findings suggest that beer consumption might not be the primary driver of the differences in nutrient intake observed, which could instead be influenced by broader dietary and lifestyle factors.

Overall, while some variability exists, the data indicates that both groups generally align with the recommendations for protein and, to a lesser extent, carbohydrates and PUFA. Moreover, many nutrients were collected only in single studies, such as total fat, fibre, sugars, certain vitamins and minerals, and therefore no conclusions could be drawn.

Although chronic alcohol consumption has been associated with impaired nutritional status and reductions in serum levels of folate, PLP, and vitamin B_{12} due to multiple mechanisms,[58–60] the effects of moderate beer consumption on biochemical parameters remain unclear.

Our systematic review found limited and inconsistent evidence, with most biomarkers assessed in single studies only, precluding meta-analysis. For those evaluated in more than one study, such as α-tocopherol and B-complex vitamins, findings were contradictory. This variability may be attributed to methodological differences, participant characteristics, study design, the quantity and type of alcohol consumed, the duration of the intervention, and the biochemical markers selected.

Moreover, the intake thresholds defined as "moderate" in the included studies often exceeded current low-risk alcohol consumption guidelines, raising questions about whether truly moderate consumption—as defined by current recommendations—might yield different results. Consequently, no consistent patterns could be established.

This systematic review with meta-analysis has several strengths and limitations.

First, it differs from an existent one that primarily focuses on the relationship between moderate beer consumption and weight status. This is the first systematic review and meta-analysis to examine observational and interventional evidence on the relationship or effect of moderate beer consumption *versus* abstention on dietary and biochemical markers of the nutritional status.

Second, it used a rigorous search strategy across four major databases, covering a broad publication range to ensure comprehensive literature inclusion.

Third, the methodological approach was robust, incorporating independent double screening of titles and abstracts by two researchers, thereby reducing potential selection bias and enhancing reliability.

Nonetheless, this review also has some important limitations, some of which are inherent to the available literature itself.

First, the number of observational and interventional studies designed to evaluate the relationship or the effect of moderate beer consumption on the nutritional status was limited. This limitation was particularly evident in the analysis of biochemical parameters, as most biomarkers were assessed in single studies only. This prevented the conduct of meta-analysis for these outcomes and hindered the identification of consistent patterns, thereby limiting the strength and interpretability of the findings in this aspect.

Second, most included studies were of fair quality and showed high heterogeneity in design, methodology, and outcomes. Although most interventional studies were randomized controlled trials, they frequently reported only intra-group differences (pre–post intervention) without inter-group comparisons. Many were short-term with small sample sizes, limiting statistical power and the detection of long-term nutritional effects or subtle dietary changes. Combined with the variability in statistical methods and inconsistent control of key confounding factors – such as age, gender, body mass index, physical activity, or socioeconomic status –, these issues hinder the interpretation of whether observed associations or effects are attributable to the moderate beer consumption itself or to other lifestyle and contextual influences. As a result, the robustness and generalisability of the conclusions are limited, and further research with larger and longer-term interventions is warranted.

Third, inconsistency in key definitions and methodologies across studies introduce further variability. This includes six major sources of heterogeneity:

(i) Lack of standardised definitions and thresholds for 'moderate alcohol consumption'. There is considerable debate about what constitutes 'moderate alcohol consumption', as definitions vary widely among researchers. In our study, only a few researchers provided a clear definition of 'moderate alcohol consumption'. The thresholds set by studies varied considerably, ranging from a minimum of 10 to a maximum of 30 g day^{-1} for women and from a minimum of 20 to a maximum of 40 g day^{-1} for men. Furthermore, it is important to recognize that the thresholds identified as moderate consumption in most of the studies included in this work were higher than the current recommended low-risk limits of 20 g

day^{-1} for men and 10 g day^{-1} for women, as set out by several countries.[61] In fact, of the studies included in this systematic review and meta-analysis, only one study[30] adhered to the current low-risk drinking guidelines. This heterogeneity presents a significant challenge for synthesising and comparing findings across studies, contributes to inconsistencies in the observed associations, and precludes the possibility of drawing robust and generalisable conclusions. Moreover, the limited number of studies using standardised low-risk thresholds prevented the possibility of stratifying the analyses or applying stricter inclusion criteria, which would have further reduced an already scarce evidence base.

(ii) Criteria for beverage alcohol preference. Most studies considered participants to be beer consumers if beer presented 60% to 70% or more of total alcohol intake. However, in practice, it is rare to find population groups that exclusively consume beer as their sole alcoholic beverage. Most individuals who consume beer also consume other alcoholic beverages, such as wine or spirits, depending on cultural habits, social context, or personal preferences. This mixed consumption pattern makes it difficult to isolate the specific effects of beer on nutritional outcomes, as the cumulative effects of other types of alcohol might influence the results.

(iii) Methods used to assess alcohol consumption and dietary intake. A variety of tools were used to collect data, including questionnaires, food records, dietary history, FFQ, interviews– each with varying degrees of bias. In particular, most observational studies relied on FFQs that were not always validated specifically for beer consumption, which may affect the reliability of the estimates.

(iv) Differences in the definition of a standard drink for beer, which ranged from 10 to 14 g of alcohol per unit.

(v) Classification methods used to categorize beer or alcohol consumption levels, which differed substantially among studies.

(vi) Definition of 'abstainers', which varied widely across the studies, from lifelong non-drinkers to those individuals who had abstained for the past 12 months. This heterogeneity also affects the comparability and interpretation of groups differences.

Together, these inconsistencies hinder the synthesis of findings and limit the interpretability of the results. The limited number of studies, combined with the wide range of variables assessed and inconsistencies in definitions and methods, including the classification of moderate consumers and abstainers, hinders the synthesis and interpretation of the data, making it difficult to draw meaningful conclusions.

In addition, while the meta-analysis provides a summary of the associations between moderate beer consumption and dietary indicators, the scarcity of data from interventional studies makes it difficult to determine whether beer consumption directly causes these changes in diet or nutrient intake, or whether they may be explained by other lifestyle factors.

Fourth, contextual drinking patterns were not considered in any of the analysed studies. Despite the recognized importance of such patterns in understanding the effects of alcohol on health, including drinking with meals and within a social context, none of the studies included addressed these factors. This omission limits the interpretation of the findings, as contextual drinking behaviours may influence both dietary intake and the metabolic effects of alcohol, thus acting as potential confounders or effect modifiers.

Finally, the lack of sex-specific results in most studies limits the ability to explore potential differences in nutritional outcomes between men and women. This represents an important limitation, as the association/influence between moderate beer consumption and dietary or nutritional outcomes may differ by sex.

Despite these limitations, this review provides a critical overview of the available evidence and identifies major methodological gaps in the literature. It thereby lays the groundwork for the harmonisation of study designs, definitions, and analytical approaches in future research on moderate beer consumption and nutritional outcomes.

4.1 Future research perspectives

To advance the understanding of moderate beer consumption and its effects on nutritional status, future research should focus on well-designed observational or interventional studies involving homogeneous groups. These groups should comprise both abstainers and beer drinkers, strictly classified according to low-risk consumption guidelines (total alcohol intake $\leq$20 g day^{-1} for men, $\leq$ 10 g day^{-1} for women). This approach would enhance comparability and reliability. Furthermore, it is essential to standardize the concept of preference beer consumption to reduce variability and minimise bias introduced by mixed alcohol consumption patterns.

Additionally, future studies should systematically assess contextual drinking patterns, such as alcohol consumption with meals, in social settings, or at specific times of day, which may help explain variations in dietary intake and physiological responses observed across populations. Furthermore, sex-specific analyses should be incorporated to account for biological and behavioural differences in dietary responses and in the metabolism of alcohol from moderate beer consumption. Addressing these dimensions will not only strengthen the methodological rigour of future research but also generate more precise and actionable evidence to inform nutritional guidance and public health policies.

5. Conclusions

The current evidence on the relationship between moderate beer consumption and dietary or biochemical parameters of nutritional status is insufficient to draw definitive conclusions.

While some differences in dietary patterns, food consumption, and nutrient intake were observed between beer drinkers and abstainers, overall diet quality appeared broadly similar across groups, according to the available data.

However, these findings should be interpreted with caution due to the considerable heterogeneity among studies, and the frequent lack of adjustment for key confounding factors such as physical activity, socioeconomic status, and baseline diet quality.

The potential effect of moderate beer consumption on biochemical markers of nutritional status remains uncertain.

Future research should be more comprehensive and include well-designed studies with homogeneous groups. These studies should adopt clear definitions of moderate consumption aligned with current low-risk alcohol guidelines and ensure robust control of confounding variables.

Author contributions

Conceptualization, R. M. O., L. G. G-R. and L. M. B.; methodology, R. M. O., L. G. G-R., L. M. B., I. C. R., A. M. L-S. and A. A.; formal analysis, L. G. G-R., I. C. R. and L. M. B.; investigation, L. G. G-R., I. C. R., A. M. L-S., A. A., E. R-R., V. L-K., M. C. L-E., E. C-S., A. P-S., M. D. S-G., R. M. O. and L. M. B.; data curation, L. G. G-R., I. C. R., A. M. L-S., A. A., E. R-R., V. L-K., M. C. L-E., E. C-S., A. P-S., M. D. S-G., R. M. O. and L. M. B.; writing – original draft, L. G. G-R., I. C. R. and L. M. B.; writing – review and editing, A. M. L-S., A. A., E. R-R., V. L-K., M. C. L-E., E. C-S., A. P-S., M. D. S-G., R. M. O. and L. M. B.; visualization, L. G. G-R., I. C. R., A. M. L-S., A. A., E. R-R., V. L-K., M. C. L-E., E. C-S., A. P-S., M. D.S-G., R. M. O. and L. M. B.; supervision, R. M. O.; project administration, R. M. O., L. G. G-R. and L. M. B.; funding acquisition, R. M. O. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

Rosa M. Ortega is a member of the Scientific Committee of the Forum for the Investigation of Beer and Lifestyle (FICYE, for its acronym in Spanish: *Foro para la Investigación de la Cerveza y Estilos de Vida*). This role is unpaid and has not influenced the conduct or reporting of this study. The other authors declare that they have no conflicts of interest. All authors affirm their independence in the design, conduct, analysis, and publication of this research.

Data availability

The dataset generated comprises data extracted from studies that were included in the meta-analysis. Studies with insufficient data for meta-analysis were analysed descriptively and are not included in the shared dataset. Some data were standardised or adapted to ensure comparability across studies, including conversions of energy units and nutrient intakes as described in the methodology. This dataset will be made publicly available *via* the Zenodo repository upon publication. All data were obtained from publicly available published sources, which are cited in the reference list.

The meta-analysis dataset is attached to this submission as ESI 3.†

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