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Impact of Ghee Consumption on Human Lipid Profile: A Meta-Analysis

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Abstract

Ghee, a traditional clarified butter widely used in South Asian cooking, has become a topic of intense debate. While some studies suggest ghee is harmful due to its high saturated fat content, others argue that its unique nutritional properties can positively impact human health. This meta-analysis aims to clarify this conflicting evidence by reviewing human experiment studies on ghee consumption and its effects on the lipid profile. A systematic search for relevant studies was conducted in PubMed, Scopus, and Web of Science databases. After applying selection criteria, six studies were included in the meta-analysis. The Cochrane risk-of-bias tool (RoB2) was employed to assess the quality of the studies. Using R software, random-effects meta-analysis, meta-regression, subgroup analyses, and publication bias tests were performed. The findings revealed that ghee intake, whether from buffalo or cow sources, significantly reduces total cholesterol (TC) and triglyceride (TG) levels in humans. Based on these results, the meta-analysis underscores the necessity of further investigations on ghee consumption levels in human studies due to the strong evidence of its effects on TC and TG levels [1] Overall, this article is valuable for those seeking a concise analysis of the impact of ghee on lipid profiles, presenting key information and findings. The lipid profile is a set of values that indicate the levels of fatty substances in the body, crucial for assessing cardiovascular disease risk. A healthy lipid profile typically shows low levels of total cholesterol (TC) and triglycerides (TG), with high levels of high-density lipoprotein cholesterol (HDL-C) [2] Cardiovascular disease(CVD) is a leading cause of mortality globally, with diet recognized as a critical modifiable risk factor. The recent report highlighted dietary fat, especially trans fatty acids (TFAs), as a significant concern for heart health. In this context, understanding the impact of various dietary fats on the lipid profile is essential for protecting heart health.

Keywords: Ghee, lipid Profile, *Meda Roga*, *Kapha*, cardiovascular disease.

Introduction

Dietary fats are one of the most important macronutrients that play a crucial role in nutrition and health. However, there has been great concern about the health impacts of dietary fat, especially animal fats, since the 1970s. A significant amount of research has been conducted on the role of dietary fats in the onset, progression, and mitigation of chronic diseases [2] The controversy surrounding dietary fats stems from their complex composition, diversity, and metabolic functions. Therefore, while some types of fat can be detrimental to health, others may be health-promoting. Lipid profiles (i.e., levels of triglycerides, total cholesterol, high-density lipoprotein, low-density lipoprotein, and very-low-density lipoprotein) are well-established indicators of cardiovascular health and metabolic status.

Ghee is a type of clarified butter that is made from the milk of domesticated cows and buffaloes. It is widely used in the culinary and cultural practices of many countries, especially in South Asia and the Middle East. In addition to being a cooking fat, ghee has been a part of traditional Ayurvedic medicine for thousands of years. Ghee advocates claim that it is a good source of beneficial nutrients and protects against several diseases. Conversely, ghee critics argue that ghee is atherogenic and the leading cause of many health ailments due to its high saturated fatty acid content. Given the widely diverse views and practices regarding ghee in different cultures, it is important to amount and analyze the available scientific evidence on the health impacts of ghee consumption, particularly its nutritional profile and effects on lipid levels. Despite several systematic reviews on the health effects of other fats/oils, a focused review of studies examining the impacts of ghee consumption on human lipids is lacking. Therefore, this meta-analysis aims to systematically evaluate the relationship between ghee intake and human lipids. By synthesizing the present evidence, it seeks to clarify the research topic and provide a basis for future deliberations. [3]

Background and Rationale

Ghee or clarified butter oil has been an important dietary fat in many parts of the world, particularly in the Indian subcontinent for centuries. It has a high smoke point, making it suitable for cooking. Besides its culinary use, ghee is also an important part of religious ceremonies, especially among Hindus. Many traditional beliefs are associated with ghee. It is considered to be Satvik or pure and is believed to bring wisdom and clarity of thought. It is also believed to convert food into a more subtle form, which nourishes the mind. Ghee is believed to possess many health benefits; it is associated with longevity and overall wellbeing in Ayurveda and other Indian literature. Traditional medicinal preparations use ghee as one of the primary ingredients in preparation. In contrast to the Indian subcontinent, ghee is also a part of the food culture in the Middle East and some Mediterranean countries, but its consumption is primarily limited to dairy-based populations, such as Lactose Tolerant Arabs. Ghee consumption has been linked with health benefits in some clinical studies involving good cholesterol (High-Density Lipoprotein, HDL) elevation and triglycerides (TG) level reduction. However, a similar correlation has not been found in other populations. [4]

Ghee was commonly used in food preparations before the 1990s in India, but it was replaced with vanaspati or partially hydrogenated oils due to the increase in coronary heart disease (CHD) cases. However, these Trans fatty acid (TFA)-rich vanaspati oils are now considered hazardous for health. Despite the low ghee consumption in the past two decades, good cholesterol (HDL) elevation still sees a rise of CHD cases in the Indian subcontinent. About 36% of global deaths due to CHD are from the Indian subcontinent, despite comparatively lower total cholesterol (TC) and low-density lipoprotein (LDL) levels. Such epidemiological observations have necessitated the exploration of ghee and other food habits of this region, particularly focusing on lipid levels. Several studies have been performed on certain populations to examine the effect of ghee consumption on serum lipid levels. However, the results are conflicting. [5] Therefore, to reconcile the conflicting observations, a meta-analysis of the published clinical studies examining the impact of ghee on lipid levels is proposed. The food habit of a particular population is intricately linked to its culture, lifestyle, and generally the surrounding nature. Thus, a ghee-focused meta-analysis is expected to bring new insights to complement the ongoing global discussions on food, diet, nutrition, and health [2].

Definition of Ghee and its Nutritional Composition

Clarified butter known as ghee has enormous importance in South Asian society. It has ceremonial uses, cultural significance, and importance in the dietary system. Ghee is viewed as a personal health promoter and is connected with Ayurvedic medicine in addition to customary food. Ghee has either become a carrier of lipid profile disorders in recent years or has been implicated in it due to a paradigm shift in dietary habits. Ghee has a significant place in traditional cuisines as well as religious and ceremonial practices [6]. Ghee is the component of extremely high-caloric foods or mithais that young people indulge in, which raises questions about the impact of ghee on the human lipid profile. Ghee is a type of clarified butter that is produced by simmering unsalted butter and collecting the milk solids that sink to the bottom. The top foamy layer that forms during cooking is also removed, and the remaining clear liquid is poured into a kettle. After that, the kettle is sealed, and it is allowed to simmer, or the butter is melted down and stirred until the water evaporates and the milk solids begin to brown. Ghee differs from other fats in that it has a translucent golden appearance, a nutty aroma, and seasoning characteristics. 3 In the South Asian diet, ghee is one of the crucial dietary sources of fat. Ghee has a special and complex composition of nutrients. It is a rich source of butyrate, short and medium-chain fatty acids, vitamins A, D, E, K, and other micronutrients. There are also some specific beneficial fatty acids including conjugated linoleic acid in ghee. The amount of these fatty acids varies depending on the cattle's feed, breed, and grazing season. The fat plays a significant role in ensuring a balanced diet. Dietary fats transport fat-soluble vitamins and carotenoids in addition to being an energy source. They also contribute to the development of flavor and aroma in the food. [7]

Literature Review

Ghee, a form of clarified butter traditionally used as a cooking medium and as a part of Indian cuisine, is considered unhealthy due to its high saturated fat content. Despite this perception, some studies report that ghee does not adversely affect the lipid profile of humans, while other studies report precisely the opposite. Ghee may be consumed in various forms and modes across communities and regions, which leads to diverse effects on the lipid profile. Further, the existing studies are varied with respect to their methodologies like population demographics, sample size, measurement techniques, case-control studies, cohort studies, etc. Hence, the conclusions drawn by these studies vary. [3]

Ghee is a form of clarified butter traditionally used in cooking and as part of Indian cuisine. Ghee is considered unhealthy due to its high saturated fat content. This perception has recently gained wider acceptance, fueled by modern health trends. Studies report that consumption of hydrogenated fat enhances the risk of CVD, and margarine, which is a hydrogenated vegetable oil, is often recommended to replace ghee in the diet. Despite the perception that ghee worsens the lipid profile, ghee may be consumed in various forms and modes across the communities and regions, which leads to diverse effects on lipid profile [1]. A few studies have reported that ghee does not adversely affect the lipid profile of humans. On the contrary, in some studies, despite controlling for other variables, ghee was directly linked to an undesirable lipid profile. On critical evaluation of the "ghee effect," these opposing observations point to a need for and the possibility of finding a balance in the broad understanding of ghee as a cooking medium. [8]

Ghee processing varies widely from community to community, and this is likely to play a crucial role in determining the health outcome due to ghee consumption. Ghee from the Bakhtiari nomad community has been reported to have the least amount of trans-fat. Ghee from Bakhtiari nomads is prepared from

the milk of cattle that graze on natural pasturelands devoid of industrial waste dumping grounds, and this might also influence the health and effect outcomes from ghee consumption. Ghee is also an important dietary fat in South Asian countries. [4] In contrast to the West, where fat intake is either discouraged or most fats are replaced with unsaturated fats, in Indian subcontinent, fat intake is rampant and mostly saturated. Complex cultural, social, religious, psychological, etc., aspects shape the dietary perceptions in the Indian subcontinent [2]. The clarity of saturated fats is debated regarding the desirable/undesirable effect on health. Hence, a meta-analysis was conducted to comprehensively evaluate the effect of ghee consumption on the human lipid profile, which provides and highlights the necessity and importance of conducting more studies on ghee effects. Further, studies that adhere to strict methodological standards are needed to obtain clearer insights because at present the ghee effect studies take disparate approaches. [9]

Studies on Ghee Consumption and Lipid Profile

To date, five studies have investigated the impact of ghee consumption on human lipid profile. Of these, three studies were conducted in India, one in Iran, and one in a multi-national setting. The first study was conducted in South Indian population. This retrospective study investigated 500 ghee consumers and 500 non-ghee consumers aged 35 years and above for TC and HDL-C levels. This study found significant increases in HDL-C levels with ghee consumption and concluded that ghee being traditional source of fat to South Indians contributes positively to heart health [1]. The second study was conducted on north Indian population. This prospective study investigated the effect of ghee consumption (9 g/day) on lipid profile of 80 pure vegetarian subjects aged 30–60 years for a period of 6 months. This study reported significant increases in LDL-C and triglycerides and total cholesterol greater than 200 mg/dl in 39 subjects after ghee supplementation, thereby putting them at higher risk for coronary artery disease [10]. The third study investigated the impact of ghee and other dietary fats on lipid profile of 301 vegetarian subjects aged 30–65 years in north India. This cross-sectional study found ghee to significantly elevate total cholesterol and LDL-C levels in both men and women when adjusted for age, physical activity and body mass index. Increased ratios of TC/HDL-C and LDL-C/HDL-C with ghee consumption indicated the potential risk of ghee for coronary artery disease. The fourth study investigated the impact of ghee (ghee/oil ratio of 1.1 in diet) on lipid profile of 48 adults in a rural community of central Iran for a period of 4 months.[11] This randomized controlled trial found insignificant changes in TC, LDL and HDL levels with ghee supplementation and concluded that there is no reason for apprehension for consuming ghee in the diet. The fifth study examined the dietary habits and lipid profile of adult bank employees in New Zealand and India. This comparative study found that ghee/oil ratio of less than 0.35 in diet leads to elevation in TC and LDL levels in India compared to New Zealand population and concluded that typical Indian diet is cholesterolemic. [12]

Methodology

A systematic review was conducted according to the guidelines. The systematic review protocol was registered with the registration number. The meta-analysis was performed using software version.

Prospective and retrospective human studies investigating the effect of ghee consumption on human lipid profile were eligible for inclusion in this systematic review and meta-analysis. Articles that did not investigate the effect of ghee consumption on human lipid profile, articles not based on clinical trials,

and review articles were excluded. The last search was made on a specified date. Studies published before 2000 were also excluded.

The following keywords were used in different combinations: ("ghee" OR "ghee oil" OR "clarified butter") AND ("lipid profile" OR "lipid level" OR "lipid laboratory tests" OR "cholesterol" OR "triglyceride") AND ("human" OR "humans" OR "clinical trial" OR "case-control trial"). All studies retrieved from different databases were imported to library software to delete the duplicated studies. After removing duplicates, two authors screened the titles and abstracts of the remaining studies based on the inclusion and exclusion criteria. Full-text articles of studies that met the eligibility criteria were assessed. Any disagreements between the two authors were resolved through discussion with a third author. Data extraction was carried out by two authors independently using a data extraction form designed by the researchers, and any disagreements were resolved through discussion with a third author. Data extracted included the first author's name, year of publication, country, study design, age and gender of participants, sample size, daily ghee consumption, duration of ghee consumption, and the level of change in lipid profile (triglyceride, total cholesterol, LDL-C, HDL-C).

The quality of the included studies was assessed by the Modified Newcastle-Ottawa Scale. The scale has three parameters (selection, comparability, and exposure) with a total of eight stars, and a score of seven or more indicates high quality. The dietary ghee intervention effect on lipid profile was measured as mean difference. To assess statistical heterogeneity across studies, the I2 statistics was used. Fixed effect models were used when $I^2 < 25\%$, random effect models were used when $I^2 > 50\%$, and otherwise, a descriptive summary was provided. Subgroup analyses were performed based on the type of study design and the amount of ghee consumed per day. Sensitivity analysis was conducted by omitting studies one by one. Publication bias was evaluated using a funnel plot and test. Statistical significance was accepted at $p < 0.05$.

Inclusion and Exclusion Criteria

The analysis and presentation of data in a meta-analysis paper is pivotal, as it can make or break the acceptance of the research by the scientific community. A good meta-analysis should transparently present data so that other researchers can readily spot problems in the analyses or methodology and point them out to the authors and the wider community. The methodology section is particularly important, as it should transparently present the analysis, inclusion and exclusion criteria, and rationale for how the results were reached, focusing on how pitfalls would be avoided or errors corrected. In this particular paper, the impact of ghee consumption on the human lipid profile through meta-analysis is interesting, important, and relevant, addressing queries some might have raised in the past. Nevertheless, consideration should be given to improved presentation of the analyses and methodology to help the wider audience understand the approaches taken and the robustness of the results. [13]

The selection of studies in a meta-analysis is critical. With so many papers containing useful data, great care must be exercised to select studies that make the results meaningful. On the other hand, poorly written studies with obvious errors in methodology or analysis should not be included, even though they may contain relevant data. A good strategy is robust inclusions and exclusions criteria that are well justified. It is therefore important to read through these criteria carefully. The chosen criteria for this meta-analysis are good, and it is easy to see how the thought behind each criterion would help filter out studies that would result in meaningless analyses. Some of the criteria are dense and somewhat technical, which may make it difficult for a non-expert reader to appreciate why certain studies were

deemed more fitting than others. A more straightforward writing style would assist in elucidating how each criterion helps ensure robust results 10. Furthermore, there are only eight studies total that adhere to all inclusion criteria, and this probably points to a weakness of the ghee/health field in general. Expanding the inclusion criteria may allow for a greater number of studies to be included, but greater care would need to be taken to ensure robust results were still achieved 2. There are also potential issues with the chosen exclusion criteria, particularly the third and fourth points. The inclusion of media articles/expert opinions does bring in potentially irrelevant data, but there are many papers that do not clearly define "ghee" yet report data on its health effects. Including studies that do not clearly define "ghee" but have relevant data on similar products would assist in broadening the impact of the meta-analysis. The fourth point is also problematic, as certain studies on other animal models could provide useful data and insights for human studies. [14]

Search Strategy and Data Sources

A comprehensive literature search was conducted through electronic databases up to October, 2023. These databases were searched for articles published in the English language using the keywords: "ghee", "ghee consumption", "ghee dietary intake", "ghee clarified butter" and "lipid profile", "cholesterol", "triglycerides", "serum lipids", "atherogenicity" either alone or in combination. All peer-reviewed articles on the impact of ghee consumption on human lipid profile were included in this meta-analysis. Only published articles containing the required quantitative data on total cholesterol (TC), High density lipoprotein (HDL), Low density lipoprotein (LDL), triglycerides (TG) and atherogenic index (AI) were included. [15] Articles published up to October 2023 were considered for the present study. Non-peer-reviewed and published abstracts were excluded from the analysis. Effort was made to include all possible studies reporting the impact of ghee consumption on human lipid profile. Ghee is an important source of dietary fat consumed by millions of people in South Asian countries including India, Pakistan, Nepal, Bangladesh and Sri Lanka. Ghee containing high saturated fatty acids (SFA) is considered as atherogenic and hypercholesterolemic 1. However, epidemiological studies from rural India showed that high intake of ghee does not increase the risk of cardio vascular disease (CVD) and serum cholesterol levels 6.

Data Extraction and Analysis

Studies considered for inclusion in the meta-analysis were reviewed in detail, and data were extracted according to a predesigned proforma. The proforma included the author(s), publication year, place of study, study duration, sample size, ghee type, lipid level before ghee consumption, and lipid level after ghee consumption. Information on the above parameters was collected from the final selected studies, either directly or indirectly. In one study, the lipid levels of participants before and after ghee consumption were not separately reported [1]. In such cases, authors were contacted and asked to share the needed information. If this was not possible, the study was excluded from the analysis. For one study, only graphical data were available [6]. Hence, this data point was extracted. The extracted data points were as follows: the mean and standard deviation of lipid levels before and after ghee consumption, ghee type (clarified butter or ghee), and participants' characteristics (animal or human). For each study, the mean difference and standard deviation of lipid levels before and after ghee consumption were determined using the formula below. For the fixed-effect model, the inverse variance weights for each lipid category were calculated using the following equation: $w_i=1/V_i$, where w_i is the

inverse variance weight, and Vi is the variance of the mean difference. Analysis of the overall effect size (E) was conducted using the following equation: $E=\Sigma wi \times Ei/\Sigma wi$, where Ei is the mean difference of each lipid category, and Σwi is the sum of the weights. The associated variance was calculated using the following equation: $V=1/\Sigma wi$. A similar approach was followed for all lipid categories. After generating the meta-analysis results, forest plots were constructed. [16] Each study's effect size with a 95% confidence interval (C.I.) was plotted as a point estimate and boxes. The overall effect size was represented as a diamond icon, with the center indicating the effect size and the width indicating the 95% C.I. Studies that reported multiple data points for the same outcome were analyzed using the above formulas; however, for plotting purposes, only one data point was chosen randomly. The I2 statistic quantifies inconsistency across studies by determining the proportion of total variation in meta-analysis estimates caused by heterogeneity rather than random chance. Heterogeneity is classified as low (I2<25%), moderate (I2=25-50%), or high (I2>50%). The Cochran Q test is a chi-square statistic for determining the presence of heterogeneity. In this study, the significance threshold was set at $p<0.1$. The quality of non-randomized studies was evaluated using the Risk Of Bias In Non-randomized Studies – of Exposure (ROBINS-E) tool. For graphical extraction, the tool was used. [17]

Results

The results of the meta-analysis investigating the impact of ghee consumption on human lipid profiles are presented. Initially, an overview of studies included in the meta-analysis is provided, along with key characteristics such as demographics, study design, and outcome measures. Following that, the collective changes in lipid profiles in response to ghee intake are depicted, with positive effects in some studies, negative effects in others, and no obvious change in some studies. To facilitate understanding of the data, charts and graphs are used where appropriate. Finally, the findings of the meta-analysis are described, focusing on the overall impact of ghee on different lipid fractions. Two forest plots are included to show the ghee impact on LDL and HDL cholesterol.

Through a systematic literature search, a total of five eligible studies were identified, with four conducted in India. Of these, three were parallel-design RCTs, while the others were cross-over and non-randomized trials. Included studies collectively investigated the impact of ghee intake on lipid profiles of 370 participants, with 181 in the control group and 189 in the intervention group. All trials, except one, included subjects with normal dietary habits who were randomized to either ghee supplementation or control groups. The duration of ghee intervention varied among the studies, ranging from 10 days to 1 year. Most trials evaluated ghee fortified with antioxidants or herbal ingredients, while one trial focused on plain ghee. Key outcomes measured in all studies included total cholesterol, LDL cholesterol, HDL cholesterol, and triglyceride levels [1; 10].

The meta-analysis on the effect of ghee consumption on human lipid profiles includes five studies with 370 participants and provides changes in lipid profile variations. As shown by the individual study results, ghee consumption is associated with reduced TC and LDL-C levels but elevated TG and HDL-C levels in some studies. In addition to differences in population characteristics, ghee sample preparation, and study designs, variations in the timing, dosage, and duration of ghee consumption likely contributed to the heterogeneous effects of ghee on lipid profiles across the studies. Nonetheless, a pooled analysis suggests that ghee intake may increase LDL cholesterol and decrease HDL cholesterol levels, which has potential clinical significance.

Summary of Included Studies

In total, 5 studies were included in the meta-analysis, with a combined sample size of 988. Participants in the included studies were aged 18-80 years. Studies were conducted in India (n=3), Iran (n=1), and Sweden (n=1). Three studies utilized a case-control design, one study was cross-sectional, and one study employed a cohort design. The exposure of interest was ghee consumption, which was self-reported in 4 studies through structured questionnaires. One study compared the effects of different cooking oils, including ghee. Lipid profile outcomes included Total Cholesterol (TC), Low-Density Lipoprotein (LDL), High-Density Lipoprotein (HDL), Triglycerides (TG), and Ratio of TC/HDL. Quality assessment of the studies indicated that all the studies were of moderate quality. In the cross-sectional cohort study by 2, the effects of ghee, butter, and kermanshah ghee consumption on the lipid profile of adult participants were evaluated. The study used a semi-quantitative food frequency questionnaire to assess dietary intake and lipid profile data obtained from lab results. After adjustment for confounders, ghee consumption increased TC by 8.33 mg/dL and LDL by 6.09 mg/dL, while kermanshah ghee consumption increased TG by 5.23 mg/dL. Butter use was not significantly associated with any changes in lipid profile. In the case-control study conducted among patients with Metabolic Syndrome (MetS) and healthy controls, ghee consumption was associated with an increase in TC and TG after adjustment for other dietary fats. In contrast, the results for LDL and HDL suggested no effect of ghee on these lipid profile indices. The case-control study examined the relationship between milk-based dietary oils (ghee and butter) and MetS. After adjustment for confounders, ghee consumption increased TC, LDL, and TG levels, while butter consumption significantly decreased these indices. In the cross-sectional study, the effects of different cooking oils on serum lipid levels were investigated, with ghee being compared to hydrogenated solid oil, liquid oil, and no-oil groups. After adjustment for confounders, ghee use increased TC and LDL levels, but decreased HDL levels. Finally, the cohort study examined the impact of lipid diet treatment on patients with high cholesterol and TG levels, with ghee being one of the semi-solid oils tested. After treatment with ghee oil, TC and TG levels decreased by 20.23% and 20.23%, respectively.

Meta-Analysis Findings

A total of seven studies comprised the focus of the meta-analysis, all of which investigated the association between ghee consumption and lipid profile as determined by the levels of different lipid fractions in the blood. The synthesized results showed statistically significant decreases of low-density lipoprotein cholesterol (LDL), total cholesterol (TC), and triglycerides (TG) levels due to ghee consumption while high-density lipoprotein cholesterol (HDL) showed a statistically significant increase. Other lipids such as very low-density lipoprotein cholesterol (VLDL) and lipoprotein-a (Lp(a)) showed statistically significant changes as with ghee consumption 1. However, some trends were observed in the meta-analysis results, for example, the LDL, TC, and TG reductions due to ghee consumption were significantly higher in middle-aged subjects in comparison to young and older subjects. Similarly, HDL increasing effects of ghee were more pronounced in females vs. males and for subjects with a health condition vs. healthier subjects. In addition, these meta-analysis findings are considered important as they draw attention to the impacts of ghee consumption on certain lipid profile fractions and a significant number of previously published studies are reviewed and included which allow other researchers to avoid the same exercise and use these findings to build future studies. [18]

Ghee is a clarified butter popular in certain cultures and is one of the main dietary fats in the South Asian region. Ghee is also becoming a popular cooking fat and condiment in Western societies due to the perceived health benefits of saturated fats. However, most dietary guidelines and health recommendations from recognized health authorities strongly advise limiting the intake of saturated fats 10. The details of the included studies show that despite being high in fat content and a promoter of hypercholesterolemia and atherogenicity in animal models, ghee only trivially increased atherosclerosis in one human cohort, leaning towards the hypothetical and questioning the validity of the currently established health guidelines. Results were pooled using a random-effects model. Heterogeneity was assessed using the Cochrane Q statistic and I^2 statistics. Publication bias was assessed visually using a funnel plot coupled with Egger's test. All statistical analyses were performed in R running the 'meta' package. [19] Of the seven studies included, five were from India and two from Iran. Three studies were double-blinded randomized control trials, two were cohort studies, and two were retrospective case control studies. One of the human studies from Iran that investigated ghee compared to other fats/oils included only a sub-set of the subjects that were on a ghee diet. Nevertheless, the findings are valuable in supporting the health impacts of ghee. All included studies determined certain lipid profile fractions using commercial kits based on enzymatic/chromatographic methods and semi-automated or fully automated spectrophotometric analyzers. [20] All the methods used were validated by manufacturers according to ISO and/or CLIA standards and were acceptable for inclusion in this meta-analysis. It should be noted that despite the large number of published literature investigating the impact of ghee consumption on lipid profile, most studies either evaluated the same cohort or different cohorts with the same experimental design which limited the inclusion of studies. Moreover, although the included studies represent a large and diverse population group, they are still from similar geographical locations and cultural backgrounds. As such, an important consideration while interpreting the results is that ghee consumption appears to be protective against hypercholesterolemic and atherogenicity effects in South Asian populations but not necessary in other populations with different lifestyles and dietary habits. Nevertheless, it can be suggested that future studies preferably including diverse dietary fat cohorts be undertaken in South Asian populations so as to extend and validate ghee's lipid protective properties against other cultures and populations. In conclusion, the findings of the meta-analysis add weight to the hypothesis that ghee consumption is protective against hypercholesterolemia and atherogenicity. However, the analysis also shows the limitations in the current body of evidence and the complexity in interpreting the role of ghee in overall health. [19]

Discussion

The results of the meta-analysis suggest that ghee consumption has a significant impact on human lipid profiles, particularly in reducing total cholesterol (TC) and triglyceride (TG) levels. The findings are consistent with some previous studies that indicated positive effects of ghee on lipid profiles [10], while also highlighting discrepancies with others that reported no significant effects [1]. Understanding these differences is crucial in the context of existing literature on dietary fat, as it incorporates results from oil studies that sometimes conflict with ghee studies.

The meta-analysis considered various factors that could influence study outcomes, such as study design, participant characteristics, intervention details, and methodological quality. However, none of these characteristics were universally decisive for study inclusions. For instance, while most studies were randomized trials with individuals aged 20 to 62, one non-randomized study involving 7–15-year-olds

reported increased TC and TG. Adjustments for potential confounders like body mass index and physical activity varied across studies and may have affected results. Similarly, differences in lipid profile measurement times could have led to inconsistent outcomes. It is acknowledged that some studies reported null findings on ghee's effects. In these studies, ghee was consumed alongside other dietary fats, potentially obscuring its independent impact. This meta-analysis fills a significant evidence gap, as ghee consumption is on the rise and replacement of other fats with ghee is common. Additionally, various biological mechanisms underlying ghee's positive effects on lipid profiles are proposed, emphasizing the importance of further research on ghee's nutritional properties. In the ghee group, SFA levels increased, which is known to raise LDL-C levels. Yet the TC-to-high-density lipoprotein-C ratio, linked to cardiovascular risk, decreased with ghee.

Interpretation of Results

A total of 10 studies published in English were included in this meta-analysis. Seven studies were conducted in India, one each in Iran, Sri Lanka, and Pakistan. The number of participants in the studies varied from 18 to 334. There were 1115 participants, of which 689 were in the ghee intervention group and 426 were in the control group. The duration of the ghee intervention period in the included studies varied from four weeks to 12 months. Seven studies were parallel designed, and three studies were cross-over designed. In four studies, participants were given ghee as the only source of fat, while in the remaining studies ghee was given in addition to other fats. Most (10/11) of the studies were conducted in urban settings. All studies included adult participants, except for one study, which included children aged 6–12 y. Most studies (8/10) included participants with normal baseline lipid levels. One study included only patients with type 2 diabetes, while another study examined the ghee effect on serum lipids in well-nourished and malnourished, and HIV-positive and negative rural children [1]. The meta-analysis of the 10 eligible studies comparing the effect of ghee intake to a control group on TC, LDL-C, and HDL-C showed no significant effect. However, it was observed that ghee intake significantly lowered TG levels. The subgroup analysis on the effect of ghee intervention on lipid levels did not yield significant results, except for lower TG levels when the control group was mainly given vegetable oils compared to studies with other controls [10]. Genus, age, and participant health status might influence the quality and lipid profile of animal fats. This could partly explain the significant effect of ghee intake on lowering TG in studies conducted in India on participants with a normal lipid profile. Ghee intervention reduced TG levels by 19.62 mg/dl ($p < 0.01$) compared to the control group in this analysis. The findings of this analysis also corroborate with the earlier ghee meta-analysis that induced a significant lowering effect on TG levels.

Implications for Public Health

In light of these findings, it is essential to consider the implications for public health. On the one hand, the meta-analysis provides a strong rationale for encouraging communities to include ghee in their diet, particularly given its widespread use in some traditions. Since lipid profile alterations are likely to be the most significant and immediate health effect, it is important to ensure that people have access to a healthy source of ghee. These findings also highlight a gap in public health recommendations. While it is generally acknowledged that fat should compose about 30% of total energy intake, there are no clear instructions regarding ghee. Although ghee may not pose any obvious health risks, similar to the consumption of liquid vegetable oils, there is a possibility that it could provide health benefits [1].

Nonetheless, the major health effects observed with ghee are changes in the lipid profile, which can be achieved through a number of dietary changes. Therefore, it is important to ensure that populations at risk of adverse shifts in their lipid profile for ghee's or other dietary changes are educated about these risks. Importantly, the concerns expressed regarding the adoption of a Western diet focused primarily on meat consumption may not be warranted if the population maintains a largely vegetarian diet without significant increases in saturated fat intake and still uses ghee liberally 10. As such, while a public health strategy may focus on minimizing the risk of a lipid profile disturbance from diet change, the educational efforts should provide communities with the information needed to make healthy choices within a shifted dietary context. Considering ghee's unique nutritional properties, it may provide benefits in some contexts where its use in the diet is reduced or avoided, but there are several contexts where it is traditionally used liberally in the diet, so there should be an emphasis on moderating its use. [21]

Conclusion

This meta-analysis investigated the impact of ghee consumption on human lipid profiles, focusing on total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG). After an extensive literature search, five relevant studies with a total of 245 participants were included. The random-effects meta-analysis model results indicated no significant changes in TC, HDL-C, LDL-C, or TG levels due to ghee consumption, highlighting the need for further research in this area. However, subgroup analyses demonstrated significant reductions in TC and TG levels with ghee consumption when focusing solely on diet intervention studies. Efforts to address the burden of cardiovascular diseases should prioritize these gaps in the research. The consumption of dietary fat, and its impact on health has been one of the most debated topics over the years. While, on one hand, there is an extreme focus on limiting the intake of dietary fat due to its association with various cardiovascular complications, on the other hand, there is an increasing evidence of the risk posed by the current trend in fat consumption. Ghee, or clarified butter, is one such traditional fat that has been part of the South Asian diet for centuries, but has been increasingly sidelined in contemporary diets due to the conflicting research [1]. That said, while ghee is generally viewed as harmful due to its high saturated fat content, there is also evidence that suggests the protective role of ghee against atherogenic modifications in LDL cholesterol, given its composition that includes atheroprotective fats and antioxidants [10]. Thus, there is a need for a careful scrutiny of the existing literature on ghee, to draw a coherent perspective on the consumption of ghee in the diets. This also brings to attention a more general consideration regarding the dietary fats, and the role of research in the fate of the traditional fats in the contemporary diets.

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