SciForschen
Open HUB for Scientific Research

Nutrition and Food Technology: Open Access

ISSN 2470-6086 | Open Access

REVIEW ARTICLE

Volume 9 - Issue 1

Systematic Review and Meta-Analysis Steps for Choosing Suitable Packaging Material (Case Study: Food Safety)

Behjat Tajeddin*

Associate Professor, Agricultural Engineering Research Institute (AERI), Agricultural Research, Education and Extension Organization (AREEO), Karaj, Iran

***Corresponding author:** Dr. Behjat Tajeddin, Associate Professor, Agricultural Engineering Research Institute (AERI), Agricultural Research, Education and Extension Organization (AREEO), Karaj, Iran, E-mail: behjat.tajeddin@yahoo.com

Received: 11 May, 2024 | **Accepted:** 03 Jul, 2024 | **Published:** 22 Jul, 2024

Citation: Tajeddin B (2024) Systematic Review and Meta-Analysis Steps for Choosing Suitable Packaging Material (Case Study: Food Safety) 9(1): dx.doi.org/10.16966/2470-6086.186

Copyright: ©2024 Tajeddin B. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Vitamins, minerals and essential fatty acids are vital to health. In the UK, the National Diet and Nutrition survey rolling programme estimates the intake of a range of these essential nutrients and foods that contain them. Since this programme began in 2008/2009 nutrient intakes have not improved. The aim of this paper is to evaluate vitamin and mineral intakes in the latest iteration of the National Diet and Nutrition Survey and compare these intakes with those in 2008/2009 and where possible with similar data from UK surveys going back to 1997. This paper also analysed findings from a survey of reviewing people's knowledge, habits and opinions on nutrition, vitamin and mineral intakes and supplementation to contribute to the interpretation of findings from the NDNS. Consumption of the majority of the micronutrients measured in the NDNS fell from 2008/2009 to 2018/2019. These decreases were greater in women than men and particularly worrying in younger women especially for vitamin A, riboflavin, folate, calcium, magnesium, iron, zinc, iodine and selenium. Reductions of the same micronutrients in young men were also evident and only zinc intakes have improved in older men. Poor dietary intakes are due to confusion and lack of knowledge as to what constitutes a healthy diet, lack of time and the cost of healthy eating which has increased during recent years. Nutrients can be provided from a healthy diet, but this is not being achieved. Hence a multivitamin and multi mineral food supplement is the best policy to bridge these dietary gaps.

Keywords: Vitamins; Minerals; Essential fatty acids; National diet and nutrition survey; Healthy diet; Knowledge; Opinion; Cost of food; Food supplements; Dietary gap

Introduction

Nowadays, in the world of research for the field of agriculture and natural resources, the path towards research is activities with the aim of "food security", "reducing the waste of agricultural and livestock products in the stages of post harvesting, processing and distribution", "protect of production resources", and "wealth production for the agricultural society" [1].

In the world of competition and business, in order to gain more customer satisfaction, successful industries are those that update their products and have development plans along with the progress of science and technology. In addition, what is important in food marketing and exchange policies is special attention to objectives such as supply, storage, conversion, distribution, and healthy and quality food consumption. Food packaging is closely related to supply, storage, transformation, distribution, and healthy and quality food consumption. Today, the role of engineered packaging is to protect the product against any pollution, maintain the integrity of the product, preparation, identify and introduce the product, attractiveness, ease of transportation, increasing productivity, raising awareness by printing the necessary information on the package, and the easy using. One of the ways to reach the above goalis to use current knowledge about food packaging. In other words, considering the role and position of packaging in the supply system of agricultural products in the four important axes of food security, increasing added value, reducing wastes, and saving energy [2], addressing the position of packaging in different research areas and industries can be taken a small step towards the above axes. In the past, the main role of packaging was to preserve the quality characteristics of the foods to provide the safety of the consumers. In addition to the consumer safety, the packaging features mentioned above are important now. Although the researches and investigations related to new materials in food packaging are extensive at the national and international levels, due to the multiplicity of technologies, the dispersion of treatments and the difference in research findings, it is difficult and forbidden to draw conclusions and general recommendations for the use of appropriate technology or treatment. These researches and investigations are sometimes not free of risks and the results of their findings, analyzes and final decisions may pose problems [3]. Therefore, it seems that the summary of previous researches can satisfy the request of the public and private sectors for more information about the role and position of packaging in the supply system of manufactured products. Then, by

reviewing the types of packaging materials and the packaging methods for various products, it is possible to express different strategies and prominent areas in which scientists have made significant progress in order to reach practitioners can get a reliable guide to use in their work.

As a result, to obtain the interpretations of numerous researches carried out over the past years in food packaging materials, a model can be used to summarize and analyze the projects implemented in the field of food packaging materials. It is possible to highlight the superiority of using food packaging materials (for example, nano packaging materials) over conventional materials.

Considering the worldwide dispersion of findings in the field of new materials in the food packaging, it is necessary to reach a final finding in this field. Therefore, the purpose of this article is to show the possibility of conducting a systematic study (that combines study data in a number of ways to reach a total understanding of the data) and meta-analysis (a type of statistical synthesis) method in food packaging materials, especially in terms of improving the quality and safety of foods, so that interested parties can use it for the effectiveness of their research in introducing suitable packaging materials.

Literature Review

In the packaging of a food stuffs, there are several important aspects regarding to the food safety. Since products must be safe for consumers, producers are responsible for this. Packaging materials that are in direct contact with food products should not pose a risk to human health. It is a fact that certain substances migrate from packaging materials to food, which is not prohibited, but migration may harm human health [4,5]. As the safety of materials in polymers is very important [6,7], for various packaging materials and specific chemicals, the European Commission has prepared guidelines for materials in contact with foods and regulations for plastics. They contain requirements and restrictions for the presence of potentially harmful substances. Based on the research, it has been determined in what amounts there may be a risk to health. If the migration exceeds this set value, there is a possibility of health risk. The manufacturer and producer of packaging materials is responsible for preparing the Declaration of Compliance (DoC). This declaration shows that the packaging materials comply with European directives. The buyer of the packaging material must confirm this DoC and ensure that the conditions of use correspond to the intended use of the packaging material. Therefore, both the producer and the buyer are responsible for controlling potential food safety risks that can be caused by migration. For example, in the European Plastics Regulation (EU) 10/2011, migration limits are set for various poly- and perfluoroalkyl substances. Substances that may migrate from packaging materials to food stuff above the permitted migration limits [8]. Polystyrene is also one of the most commonly used compounds for packaging of foods. It is used in beverage cups, meat, egg, yogurt and cheese containers and ready-to-eat foods [9,10,3]. Styrene of polystyrene is used in polystyrene, polyamide (a very suitable and practical packaging material using in vacuum packaging), and acrylonitrile-butadiene-styrene and it has the ability to migrate to food [11]. In another example, mineral oils are chemical oils that are mostly obtained from petroleum and may enter food in various ways and cause contamination. For instance, through the use of lubricants on machines during food production, or through hydraulic oils in production and harvesting machines, there is a possibility of mineral oils entering food. Another possible source of contamination is packaging materials. There are many foodstuffs in packages made of paper and cardboard. Paper and cardboard are often made from recycled paper, which may contain contaminants such as mineral oils from newsprint ink. These contaminants may migrate from packaging materials to food and possibly pose a risk to consumers. There are still many doubts about the dangers of mineral oils and the requirements that must be met to use packaging materials in a food-safe manner, in order to prevent or minimize migration [12]. For more example of the relationship between packaging materials and food, the coatings used for plastic and metal packaging contain the chemical Bisphenol A (BPA) may be a threat to food safety. Polycarbonate food containers may also contain BPA, which is used to make the containers transparent or more resistant to heat. BPA can pose a risk to public health. However, BPA can be safely used in food contact packaging materials. This material has been used in the production of plastics and resins (epoxy) since the 1960s. The European Chemicals Agency (ECHA) classifies BPA as a hazardous substance. When BPA is used in food packaging, its excessive amount can be transferred from the packaging to the food, and whether or not it is a risk to people's health depends on the amount that enters the food [13]. It is not bad to mention micro plastics, which may not be directly related to food safety, but they are not completely irrelevant either. They can appear in the packaging and end up in food, or when the plastic packaging is thrown away in the nature and decomposes into small particles, they are placed in the environment. Research is still too limited to comment on the impact of micro plastics in food on human health and more research is needed. Micro plastics, like nano plastics are small plastic particles. The difference between micro and nano plastics is their size. The size of micro plastics is microscopic and they are between 0.1 and 5000 micrometers (or 5 mm), and the size of nano plastics is much smaller and they are between 1 and 100 nanometers (or 0.0001 mm) [14]. The presence of heavy metals should not be neglected, and of course the definitions used for the term heavy metals are different. However, highly toxic metals that may be present in packaging materials with legal restrictions include lead, cadmium, mercury, and chromium [15].

In the recent years, systematic reviews and meta-analysis have been carried out in the various fields, especially medical and pharmaceutical cases. These research methods are powerful tools that can overcome implementation problems and research errors [16, 17]. However, there is not more meta-analytic researches that have been carried out on different areas of food packaging including the relationship between packaging materials and the safety of packaged foods. Evidently, there have been published systematic studies on consumers' understanding of smart food packaging technologies [18] and systematic studies on packaged foods with polystyrene to search for the level of styrene contamination in foods [4]. Sadeghizadeh Yazdi, et al. (2019) [19] used a systematic review and meta-analysis for application of edible and biodegradable starch-based films in food packaging. First, all of the studies related to the title were searched by using some keywords (edible and biodegradable starch-based films and food packaging) in the English databases including Google, Google scholar, PubMed, Embase, CINAHL, PsycInfo, SCOPUS and ISI web of Science during the 2010 to 2018. Data were collected based on study characteristics, edible and biodegradable starch-based films, food packaging. In the initial search, 589 articles were found that after reviewing the titles and abstract and removing repetitive and non-related, 33 possible related articles were examined. Of these, 24 articles were omitted from the abstract because of lack of access to the original article and lack of sufficient information. Finally, 13 papers were included in the study. Different needs in the food packaging industry for bio-films have led to the diverse sources of starch being studied, because each source has its own specific characteristics. Extending the use of starch structure techniques and the use of this material in combination with other

materials to reduce the inherent weaknesses of this natural polymer has led to its further development in various industries, especially packaged industries. Optimizing conditions will produce transparent, non-odorous, non-flavored, and color-free films with improved mechanical, optical and deterrent features. Sharafi, et al. (2023) [20] reviewed the use of Plant Essential Oils and Extracts (PEOE) in the development of antimicrobial edible films for dairy application by way of a systematic review and meta-analysis. According to the results, the inter quartile range of pathogen reduction potential of Essential Oil (EO) in dairy products, irrespective of EO, film and product type, was 0.10 - 4.70 log CFU g-1 percent concentration. The findings from 38 articles indicate that the choice of PEOE at appropriate concentrations with the selection of appropriate edible film may improve the safety, sensory, and shelf life of dairy products. In the other study, a two-dimensional probabilistic model has been developed to estimate the short-term dietary exposure of UK consumers to migrants from food packaging materials. The current EU approach uses a default scenario of assuming that all individuals are 60 kg weight and consume 1 kg of food packaged in the material of interest per day. Using survey for around 2000 individual's supplies detailed information on the consumption of food. As a result it is possible to address the variation in consumption of food amongst individuals, and account for actual body weights providing a more accurate representation of the 'true' exposure. Bisphenol A Diglycidyl Ether (BADGE), Di-2-Ethylhexyl Adipate (DEHA) and styrene migrants were considered as specimen compounds. The methodology employed has the flexibility to adapt to other migrants and packaging types and indeed other food contaminants. Exposure for each individual is estimated by calculating and summing the individual exposure from each item in their diet, and is repeated for all individuals in each survey to produce a distribution of exposures for the population. The packaging type of each food item is assigned by utilizing known packaging types from the database or, by sampling from a distribution based upon market share information. The parameters contributing towards the exposure from a packaged dietary item are migrant concentration and item weight. The probabilistic approach allows sensitivity analysis to evaluate the relative importance of the input parameters and places confidence bounds on the outputs to show the effect of the uncertainties and the contribution of each food type toward the overall exposure [21].

The above relevant matters show that how are packaging materials widespread, how are their uses different in the food industry, and how likely they are to create a risk to human health. Therefore, there is a need for scientists and researchers in the field of food and health, as often as possible (according to the speed of technology development today, the shorter the better), to study the findings of new technologies in food packaging globally and reach a final finding as much as possible. Such an achievement requires the use of comprehensive statistical methods, such as the systematic reviews and meta-analysis method, which shows the possibility of examining and combining the results of research conducted in the past years regarding new technologies and materials in food packaging.

Materials and Methods

Materials

To assess the risk and receive exposure to toxins and chemical compounds, it is necessary to measure the amount of these compounds in foods. A comprehensive and systematic study of these compounds not yet been performed. Due to the carcinogenicity of these compounds, in the systematic study and meta-analysis, the amount of these compounds and the type of food containing these compounds should be studied. So as to achieve the above goals, first of all, the studies and investigations carried out on new technologies in food packaging during the past years should be reviewed. These studies and reviews include all kinds of reports and scientific-research articles published in reputable scientific journals using keywords such as packaging, packaging materials, safety of packaging materials, migration of hazardous materials from packaging material to foods, shelf life, smart packaging, active packaging, nano packaging, packaging composites, packaging nano composites, biodegradable packaging, Vacuum Packaging, Modified Atmosphere Packaging (MAP), etc. in databases such as Wiley Online Library, Springer, Google Scholar, Direct Science, PubMed, ISC, etc. The information and data examined from these articles include the title of the research, various aspects of technology in terms of improving the quality and safety of food, applicability and economic variables. Then, this information is examined, screened and analyzed froman Excel file using a special meta-analysis format containing the columns of sources, country, control treatment, and experimental treatments (Figure 1).

Articles and reports are selected in such a way that they contain the necessary information for meta-analysis. This information includes the average of the investigated indicators in the control treatment and experimental treatments, the standard deviation of the mean and the variance of the test error and the number of repetitions [22].

Methods

The research steps of systematic reviews and meta-analysis in this study are briefly described below:

1 - In the systematic review aimed to investigate the level of pollution materials (in terms of quality improvement and food safety) in packed foods, the original articles including keywords packaging materials (such as styrene, bisphenol A, polystyrene, mineral oils, etc.), foods, contamination, pollution, food packaging, shelf life, etc. Should be searched in the English databases including Google, Google scholar, PubMed, Embase, CINAHL, PsycInfo, and scientific bases like Web of Science, Medline, Scopus, and Science Direct during the certain period of time [19]. For better results, in addition to English databases, should also pay attention to the local language scientific databases.

2 - Data were collected based on study characteristics, therefore, the articles that did not meet the inclusion criteria are excluded with the initial evaluation from the total of studies.

3 - The quality assessment is conducted for selected full papers and finally data are extracted from the selected articles.

4 - All necessary analysis is also conducted with some software such as Comprehensive Meta-Analysis (CMA) software.

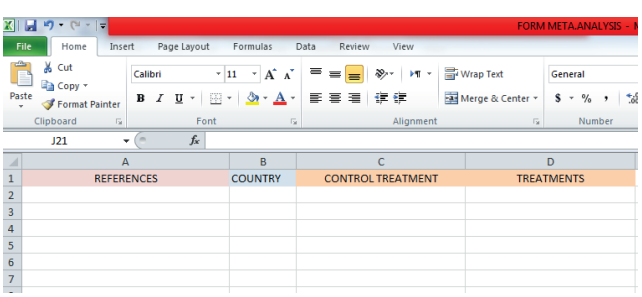

Figure 1: Meta-analysis form to extract the primary information.

5 - The examined samples may be any type of packaged food in the various packaging materials.

6 - As the shelf life of product has effect on migration of packaging materials, the overall average of migrated material is estimated in food matrix.

7 - The permissible level of dangerous substances of packaging materials in foods should be specified in accordance with the standards. For example, the Committee of the World Health Organization (WHO) and the World Food Organization have announced a tolerable daily intake of 40 mg /kg-body weight per day for styrene [21]. In addition, the European food safety authority, has announced the maximum permissible limit for styrene in food as 0.6 mg/kg. Furthermore, according to the Food and Drug Administration (FDA), the maximum allowable styrene in bottled water is 0.1 mg/L [23]. Where data on concentrations for a particular type of food are lacking, expert judgment is used to extrapolate from available data for other food types [21].

8 - The obtained amount of the number 6 should be less than the permissible level of number 7.

9 - The description of meta-analysis steps can be seen in the research of [24] as follows:

9.1 - Since the intensity or number of relationships between variables cannot be determined only with statistics or statistical tests [25], it is necessary to use the effect measurement indicators. One of these indicators is The Effect Ratio Index (R).

The Effect Ratio (R) is obtained from the ratio of the average measured traits in the research treatment (which will be determined after screening all the articles according to the above keywords) to the average traits in the control treatment (conventional technology or material compared to the research treatment resulting from the screening of all articles) [22]. In line with the subject of this article, these traits can be indicators for improving food quality and safety, applicability, and economy.

To investigate, reject or confirm the null hypothesis, tests of the significance level and the magnitude of the effect size will be studied both individually (in one research) and in a group (among all researches) [26].

9.2 - Due to the fact that a non-parametric weighted function is used for meta-analysis, the weight of each effect size is calculated as follows (Equation 1):

$$W_i = \frac{n}{y}$$

Where in:

n: The number of replicate measurements

y: The number of years or measurement samples

9.3 - The average effect size is obtained from the Equation 2 [27]:

$$In\overline{R} = \sum(\mathrm{InRi} \times \mathrm{Wi}) / \Sigma W_i$$

Where in:

InRi: Effect size for measured traits in the i comparison.

9.4 - The percentage of changes in traits resulting from the research treatment (CH %) compared to the traits resulting from the application of the control treatment (conventional technology or material) is obtained from Equation 3:

$$CH\% = (\mathrm{R} - 1) \times 100$$

Where in:

R: The effect ratio

9.5 - To analyze changes in food quality, regression analysis and mathematical functions are used if necessary.

Discussion and Conclusion

Since this article deals with the application of the systematic review and meta-analysis method in food packaging from its safety viewpoint, determining the effect ratio for each of the examined indicators will determine the popularity and effectiveness of that indicator, that is, what we are looking for it. In other words, by determining the ratio of the effect, and the percentage of changes of the investigated attribute (for example, the safety of the food in contact with the packaging material contain styrene, bisphenol A, mineral oils, etc.), a more accurate statement can be made. Therefore it was pointed out, in this paper how to use the systematic review and meta-analysis method step by step to help that using this approach to integrate the findings of numerous researches conducted over the past years regarding new technologies or materials in food packaging, shows the effectiveness and the achievement of superior results.

References

1. Anon 2024a CGIAR is the world's largest global agricultural innovation network.
2. Tajeddin B (2019) Packaging of Agricultural Products, a Strategy to Reduce Waste. Strategic Research Journal of Agricultural Sciences and Natural Resources 4: 199-212.
3. Tajeddin B, Arabkhedri M (2020) Polymers and food packaging (Chapter 16), in "Polymer Science and Innovative Applications", Deepalekshmi Ponnamma, Marcelo Carignano, and Mariam AlMaadeed (Eds.), Pp. 525- 543, Elsevier.
4. Sadighara P, Akbari N, Mostashari P, Yazdanfar N, Shokri S (2022) The amount and detection method of styrene in foods: A systematic review and meta-analysis. Food Chem X 13: 100238.
5. Tajeddin B (2017) Packaging composite materials from renewable resources (Chapter 19), in "Handbook of composites from renewable materials- volume 3: physico-chemical and mechanical characterization", Vijay Kumar Thakur, Manju Kumar Thakur, and Michael R. Kessler (Eds.), Pp. 525- 561, Wiley, Scrivener Publishing.
6. Guart A, Blay FB, Borrell A, Lacorte S (2011) Migration of plasticizers phthalates, bisphenol A and alkylphenols from plastic containers and evaluation of risk. Food Addit Contam Part A Chem Anal Control Expo Risk Assess 28: 676-685.
7. Roudsari LP, Rahmani A, Shariatifar N, Oranj BT, Mazaheri M, et al. (2020) Occurrence of Histamine in Canned Fish Samples (Tuna, Sardine, Kilka, and Mackerel) from Markets in Tehran. J Food Prot 83: 136-141.
8. Keuenhof M (2022a) Food safety and packaging. Netherlands Institute for Sustainable Packaging (KIDV).
9. Brandsch R, Schuster D (2020) Repeated use food contact materials: A categorisation approach in support of risk assessment. Food Addit Contam Part A Chem Anal Control Expo Risk Assess 37: 2184-2203.
10. Cao XL, Sparling M, Pelletier L, Dabeka R (2018) Styrene in foods and dietary exposure estimates. Food Addit Contam Part A Chem Anal Control Expo Risk Assess 35: 2045-2051.

11. Marć M, Formela K, Klein M, Namieśnik J, Zabiegała B (2015) The emissions of monoaromatic hydrocarbons from small polymeric toys placed in chocolate food products. Sci Total Environ 530-531:290-296.

12. Keuenhof M (2022b) Mineral oils in packaging. Netherlands Institute for Sustainable Packaging (KIDV).

13. Keuenhof M (2022c) Bisphenol A in packaging. Netherlands Institute for Sustainable Packaging (KIDV).

14. Anon 2024b. Where the ocean's micro plastics come from-estimated share of total micro plastics in the world's ocean, by source. International Union for Conservation of Nature (IUCN).

15. Eti SA, Islam MS, Shourove JH, Saha B, Ray SK, et al. (2023) Assessment of heavy metals migrated from food contact plastic packaging: Bangladesh perspective. Heliyon 9: e19667.

16. Conn VS, Ruppar TM, Chan KC, Jacob JD, Pepper GA, et al. (2015) Packaging interventions to increase medication adherence: systematic review and meta-analysis. Curr Med Res Opin 31: 145-160.

17. Ahn EJ, Kang H (2018) Introduction to systematic review and meta-analysis. Korean J Anesthesiol 71: 103-112.

18. Young E, Mirosa M, Bremer P (2020) A Systematic Review of Consumer Perceptions of Smart Packaging Technologies for Food. Front Sustain Food Syst 4.

19. Yazdi JS, Habibi M, Kamali AA, Banaei M (2019) Application of Edible and Biodegradable Starch-Based Films in Food Packaging: A Systematic Review and Meta-Analysis. Current Research in Nutrition and Food Science 7: 3.

20. Sharafi H, Moradi M, Sharafi K (2023) A systematic review and meta-analysis of the use of plant essential oils and extracts in the development of antimicrobial edible films for dairy application. Vet Res Forum 14: 179-194.

21. Holmes MJ, Hart A, Northing P, Oldring PKT, Castle L, et al. (2005) Dietary exposure to chemical migrants from food contact materials: a probabilistic approach. Food Addit Contam 22: 907-919.

22. Hedges LV, Gurevitch J, Curtis PS (1999) The meta-analysis of response ratios in experimental ecology. Ecology 80: 1150-1156.

23. Chiesa LM, Soncin S, Panseri S, Cantoni C (2008) Release of ethylbenzene and styrene from plastic cheese containers. Vet Res Commun 32: S319-S321.

24. Gurevitch J, Hedges LV (1999). Statistical issues in ecological meta-analyses. Ecology 80: 1142-1149.

25. Johnson RA, Bhattacharyya GK (2006) Statistics: principles and methods. 5 Edits, John Wiley & Sons, Inc.

26. Rosenthal R, DiMatteo MR (2001) Meta-analysis: recent developments in quantitative methods for literature reviews. Annu Rev Psychol 52: 59-82.

27. Huang S, Zeng Y, Wu J, Shi Q, Pan X (2013) Effect of crop residue retention on rice yield in China: A meta-analysis. Field crops research 154: 188-194.