



How the oldest preservation technique might offer solutions for the Netherlands of today

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How the oldest preservation technique might offer solutions for the Netherlands of today

A research on the health implications of raw lacto-fermented vegetables in regard to the two of the most critical diseases in the Netherlands

Bachelor Thesis

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Preface

This bachelor thesis has been written in the period between October 2019 until June 2020 at the Aeres University of Applied Science in Almere, the Netherlands under the supervision of Saima Bantvawala. I would like to thank my mentor Mrs. Saima Bantvawala for her feedback and support in those uncertain times, my biggest inspiration Mr. Sandor Ellix Katz for advocating culinary fermentation and my family and partner for encouraging and supporting me. I feel grateful to have the opportunity to write about a topic that inspires me to such an extent, personally and professionally. During my Green Starter programme at Aeres University of Applied Sciences, I have had the chance to dive deeper into the multi-layered importance of fermentation. For me, as a person who is eager to contribute to a move towards a more environmental and health-restoring food system, fermentation delivers valuable solutions. Next to environmental benefits, my interest has brought me to research gut health, cardiovascular diseases, and inflammatory bowel syndrome (IBS). Mostly, because a devastating amount of my Dutch friends show indications of the previously mentioned diseases. The scientific amount of evidence I found showing positive correlations between the consumption of raw fermented vegetables and IBS were undeniable. Although this report is limited to the relationship to the named diseases, I see great potential in promoting fermented foods, not only in the population in the Netherlands but across the globe for more beneficial health- reasons. When looking at the vast amount of sophisticated scientific proof, it is almost implausible that lacto-fermented foods have not yet been incorporated into dietary food guides across the globe.

Summary

Fermentation is known as the oldest method to preserve food and beverages in human history (FAO, 2015). Also science has picked up on the topic, continuously publishing findings analysing the health effects of consuming lacto-ferments (Katz, 2012). The Netherlands is amongst the western countries constantly fighting with diet and lifestyle-related diseases (WHO, 2017). Every fourth citizen within the Netherlands is affected by inflammatory bowel syndrome, an infection of the terminal ileum and colon (Spekhorst, et al., 2017). Next to this, cardiovascular diseases are remaining to be amongst the most frequent causes of deaths in the Netherlands (WHO, 2017). Both diseases are putting a burden on the population, the healthcare- and the economic system. The search for functional foods that deliver a cheap and widely accessible prevention and treatment of the symptoms of the named diseases has brought up the following research question:

What are the health-related benefits of including raw lacto-fermented vegetables into the daily diet of the Dutch population in regards to preventing and treating cardiovascular diseases and inflammatory bowel syndrome?

Numerous results of publication from renowned medical sources as well as studies and reports concerning this topic have been collected and evaluated to give a meta-analysis as a conceptual framework of this thesis. The results showed a clear relationship between the probiotic and prebiotic content in lacto-fermented vegetables and the restoration of gut microbiota in patients with inflammatory bowel syndrome. This results in a relief of the symptoms of the disease as well as a prevention to sicken from it (Divya et al. 2012). Next to that the pre-and probiotic contents within lacto-fermented vegetables are responsible for a substantial reduction in serum cholesterol, which is the main cause of sickening from cardiovascular diseases it (Saini, Saini, & Sharma, 2010). These results have been applied to the Netherlands to provide a concept for action to lower the numbers and alleviate the symptoms of the named diseases. The suggestion is to include the recommendation for daily consumption of raw lacto-fermented vegetables into the wheel of five, the official dietary recommendation for the Dutch population. Further education on how to prepare and how to consume lacto-fermented vegetables is recommended in order to profit from the health bringing benefits of this food group as a preventive act.

Table of Contents

<i>Table of Pictures</i>	6
<i>Table of figures</i>	6
1. Introduction	7
1.1 The importance of nutrition for health for humans.....	7
1.2 The Netherlands as the focus country.....	8
1.3 The current health status of the Netherlands and the most relevant diet-related diseases....	10
1.4 The importance of raw lacto-fermented vegetables for a healthy diet.....	11
1.5 Research question and main objective.....	12
2. Material and Methods	14
2.1 Research design	14
2.2 Selection Criteria	14
2.3 Research method according to the sub-questions.....	15
2.3.1 Sub-question 1: What are raw lacto-fermented vegetables?	15
2.3.2 Sub question 2: What is known in the literature about the impact of raw lacto-fermented vegetables on health in general?	16
2.3.3 Sub question 3: What is known in the literature about the impact of raw lacto-fermented vegetables on cardiovascular diseases?	16
2.3.4 Sub-question 4: What is known in the literature about the impact of raw lacto-fermented vegetables on IBS?	17
2.4 Literature analysis	17
3. Results	18
3.1 What are raw lacto-fermented vegetables?	18
3.2 What is known in the literature about the impact of raw lacto-fermented vegetables on health in general?	19
3.2.1 Food preservation and food security	20
3.2.2 the influence of lacto-fermented vegetables on the digestive system.....	21

3.3 What is known in the literature about the impact of raw lacto-fermented vegetables on cardiovascular diseases?	22
3.3.1 The source of cardiovascular diseases	23
3.3.2 The potential of pro-prebiotics to prevent cardiovascular diseases.....	23
3.4 What is known in the literature about the impact of raw lacto-fermented vegetables on IBS?24	
4. Discussion of results.....	27
4.1 What are raw lacto-fermented vegetables?	27
4.2 What is known in the literature about the impact of raw lacto-fermented vegetables on health in general?	27
4.3 What is known in the literature about the impact of raw lacto-fermented vegetables on cardiovascular diseases ?.....	28
4.4 What is known in the literature about the impact of raw lacto-fermented vegetables on IBS?29	
5. Conclusions and recommendations	30
5.1 Recommendations.....	31
5.1.1 Inclusion of raw fermented vegetables into dietary recommendations	31
5.1.2 Inclusion of raw lacto-fermented vegetables into the Wheel of Five.....	32
References.....	35
Appendices.....	41
Appendix 1.....	41

Table of Pictures

Picture 1 Lacto-ferments, (Ecchlebowski, 2019)	19
Picture 2, Lacto-fermentation in developing countries, (Nehal, 2013)	21
Picture 3, Inflammatory bowel syndrome, (UltraDD, 2019).....	24
Picture 4, Zuurkool (Okoko, 2020).....	26

Table of figures

Figure 1 Dutch health care expenditure per head amongst the highest in Europe, (OECD, 2017)	8
Figure 2 Life expectancy at birth in years for the Netherlands, (European Commission, 2017)	9
Figure 3, Average European live expectancy, (European Commission, 2017)	9

1. Introduction

1.1 The importance of nutrition for health for humans

What does humans concern? According to Maslow's hierarchy of needs, humans primarily care for the fulfilment of their basic needs as well as a sensation of security. Subsequently, the focus lies on their peer groups and their health. Concluding in the quote of Franklin D. Roosevelt "The success or failure of any government, in the final analysis, must be measured by the well-being of its citizens. Nothing can be more important to a state than its public health; the state's paramount concern should be the health of its people "(Century, 2012). Roosevelt implies the interest of people, the public and private sector, organizations into this concern. Economically, the overall good health of society implies more productivity in the workforce and better study capabilities for younger age-groups (WHO, 2019).

Food is one of the most important parts of our daily focus. Balanced nutrition does not only provide us with vital macronutrients: fats, carbs, and proteins which are the building blocks, providing energy and facilitating growth for the human body, but also delivering essential micronutrients, like vitamins, fibres, minerals and Phyto minerals associated to plants. Additional positive effects of well-balanced nutrition are a stronger immune system, safer pregnancy and childbirth, as well as lowering the risk of diabetes, cardiovascular diseases, and increasing life expectancy (WHO, 2019). Defining and supplying an exact plan for the right nutrition is still a conflicting operation. Science is continuously publishing new findings on the influence of different nutritional compounds, social structures, and general recommendations. Nevertheless, official bodies including the FAO and WHO conclude general recommendations based on the most acknowledged and scientific statements. Communicated dietary recommendations for private people, institutions, and government follow the guidance of those official institutions, as public communication is the prime tool to have an impact on the eating behaviour of society (WHO, 2019).

Each country chooses different communicative tools, including funding plans for campaigns, based on their clinical findings, food culture, food supply, consumer behaviour, disease profile, and other influences that have an impact on the health status based on diet (FAO, 2016).

1.2 The Netherlands as the focus country

This report has been published under the guidance of the Aeres University of Applied Sciences in the Netherlands; therefore, the main focus will lie on the Dutch population. Nevertheless, the findings of this report do not imply that they are only explicitly true for the Netherlands. Furthermore, when looking at the average costs of the European countries within the health sector it is visible that the Netherlands is ranking high above the European average, see figure 1 (European Commission, 2019). A low cost-efficiency implies the future potential for cheap and effective improvements, which will be the concern of this report. The “State of Health in the EU, country profile Netherlands” published by the European Commission, illustrates that the large spending are caused by comparatively high long-term care expenditure. Because 80% of those spending is publicly funded, the prevention of diseases is a concern of the government as well as the Dutch public (European Commission, 2019).

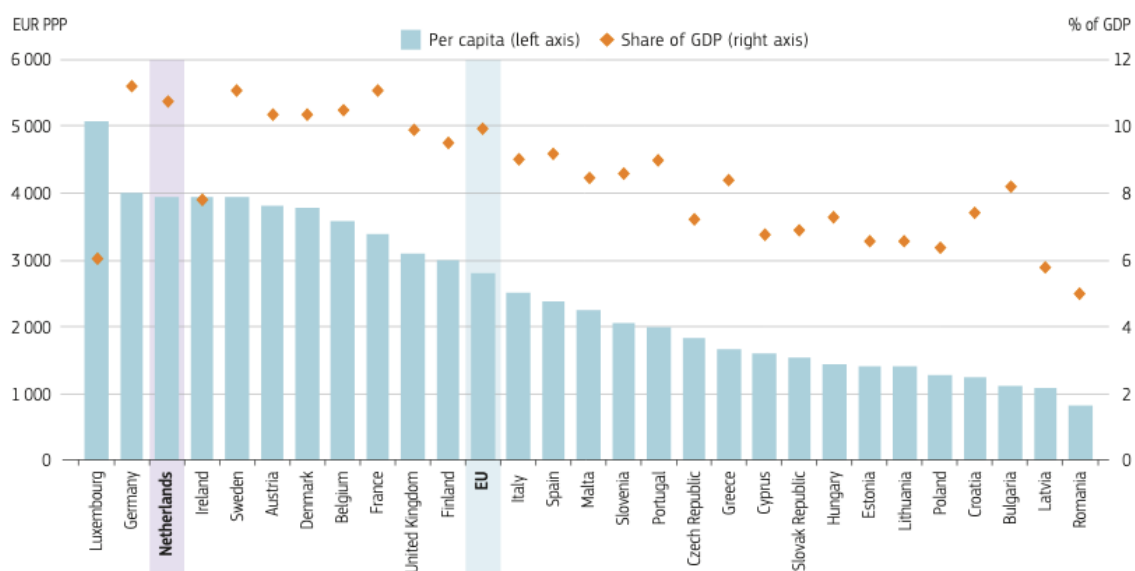


Figure 1 Dutch health care expenditure per head amongst the highest in Europe, (European Commission, 2019)

The high Dutch investment shows to be effective with a life expectancy of a citizen of 81.6 years in 2015, being one year longer than the European average of 80.6 years, see figure 2 (European Commission, 2019). Still, the quality of life remains low within the last years of life (European Commission, 2019). Thus, there is interest for Dutch individuals to improve this situation and investigate cost-effective possibilities to do so.

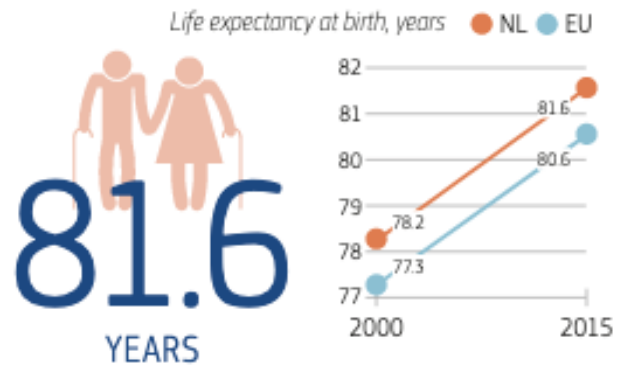


Figure 2 Life expectancy at birth in years for the Netherlands, (European Commission, 2019)

Compared with its neighbour country Belgium (life expectancy, average 81.01 years), the Dutch life 0.5 years longer (European Commission, 2019). While Germany follows with an average of 80.7 years to live for its citizens. Figure 3 shows clearly that the Netherlands has a leading position in the centre of Europe, concerning life expectancy (European Commission, 2019).

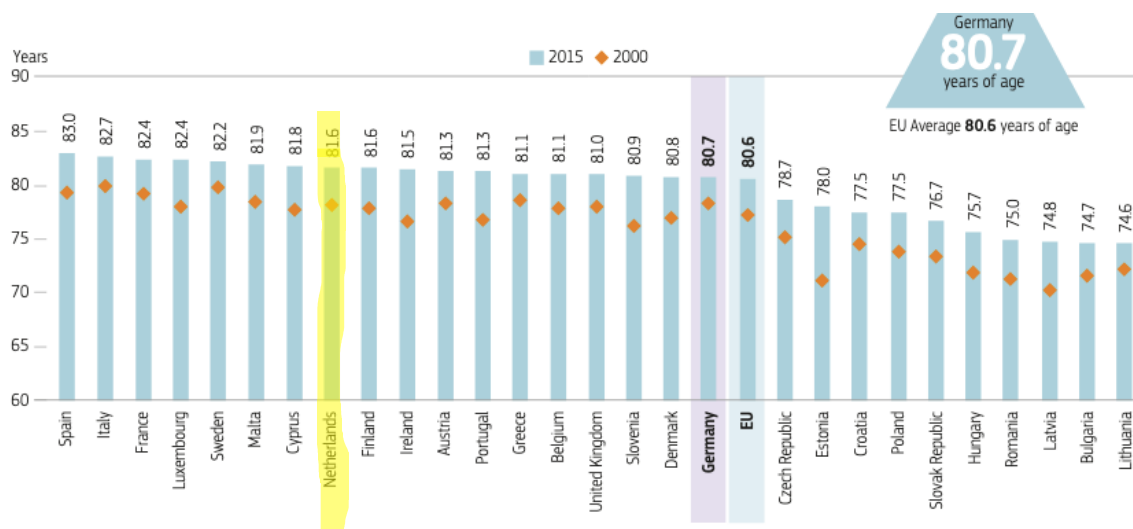


Figure 3, Average European live expectancy, (European Commission, 2019)

According to the official health profile published by the European Commission, the Netherlands is particularly vulnerable to diseases caused by behavioural risk factors, like smoking, drinking, and maintaining a poor diet, accounting for 26% of the causes for vital diseases (European Commission, 2019). This number varies by 2% more or less between other European countries (European Commission, 2019). Providing dietary recommendations to the Dutch population therefore can be considered as a preventive action for the most

concerning diet-triggered diseases, mentioned in paragraph 1.5. The cost-effectiveness of preventive actions, like dietary education, implies a small proportion of the overall costs for a full treatment and recovery. This ultimately leads to a healthier and less burdened population as well as a higher cost-efficiency for the government (Bar-Yam, 2016).

1.3 The current health status of the Netherlands and the most relevant diet-related diseases

In a report published in 2017 by the National Institute of Public Health and the Environment, Ministry of Health, Welfare and Sport Netherlands (RIVM), which is, together with the Nutrition Health Centre (Voedingscentrum in Dutch) the most important governmental body with regards to public health, that “In conjunction with smoking and overweight/obesity, dietary habits are responsible for the majority of health loss and socio-economic health differences in the Netherlands” (RIVM, 2017, p.2). Thus, they are referring to the dietary guideline that they formulate, in cooperation with “Voedingscentrum” the Netherlands Nutrition Centre, which is the recognized authority in the field of healthy safe, and sustainable food. Those guidelines are specially meant for nutrition policy, purposes to lower the risk of dietary-related diseases and are based on consumer behaviour and the recommendations by the WHO and their clinical institutions (RIVM, 2017). See specific daily diet regime of the Netherlands in appendix 1 (Voedingscentrum, 2017).

When looking at the investment into public health and the ranking of general public physical well-being, it is visible that The Netherlands is ranking relatively high with 10.9% of the GDP spent on health, compared to any other European country, ranking on the third place, only following Germany with 11.3% of the GDP spent on health and shortly above Ireland with 7.8% of the GDP spent on health, see figure 1, and the official numbers published by the WHO (WHO, 2017). Still, some concerns have become more severe over the course of the past years. According to the “country health profile” which has been published by the European Commission in 2019, cardiovascular diseases and diabetes are amongst the greatest causes of health concerns and medical deaths (European Commission, 2019). Shortly followed by inflammatory bowel syndrome (IBS), which currently concerns one-quarter of the Dutch population. Numbers are expected to rise according to the Dutch IBD Biobank, which consists of all eight university medical centres within the Netherlands (Spekhorst et al., 2017).

Although investments have tendentially risen for the health care system about 8,000 million Euros over the course of the past five years (Statista, 2018), the percentage of people sickening from those illnesses has risen (WHO, 2019). Nevertheless, the Dutch health care system is ranking so high in its effectiveness in terms of longevity, it is clear that finding the causes for those diseases and especially investing in prevention is inevitable. Understanding the causes of these fatal diseases might also lead to a plan for preventive action and might even give indications for a potential cure, thus fewer costs. What can be done to have an effective and efficient way of reducing the number of cases for IBS and cardiovascular diseases?

Like already mentioned in paragraph 1.1, dietary recommendations are a way of lowering the risk of getting sick from both cardiovascular diseases, as well as IBS. Diet and the inclusion of particular food groups play a tremendous role in preventing and healing those particular diseases (WHO, 2017).

1.4 The importance of raw lacto-fermented vegetables for a healthy diet

Food “trends” are shaping the food landscape of consumers and portrait the latest consumers’ wants and interests. Within the past two years, a food group has re-entered the picture – fermented foods. Forbes, the most influential magazine to announce food trends for the public stated in 2018, that although fermented foods include approximately one-third of the food we consume daily (Katz, 2012), fermented foods that are “unknown” like kombucha, miso, kimchi, koji, colourful varieties of sauerkraut, etc. experienced growth in consumption of 149%, becoming one of the largest trends in the upcoming years (Forbes, 2018). In particular, this report is going to examine the potentials of lacto-fermented vegetables, a specific form of fermentation including lactic acid bacteria (LAB). On a biological level, lacto-fermentation describes the transformative action of lactic acid bacteria, which are found in everything that is potentially consumable for the human species, while preserving and transforming vegetables over a long period of time (FAO, 2017). Lacto-fermentation is in culinary terms, one of the oldest preservation techniques, tracking back from the first forms of a civilization of humankind (González et al., 2019).

The most influential publication within the field of culinary fermentation and the general advocacy amongst the mainstream towards its numerous benefits and latest scientific findings, is “the art of fermentation” published in 2012, by Sandor Ellix Katz. The 500 pages accumulate the most actual state of scientific knowledge about the culinary use of fermentation across the globe and is bagged by scientific bodies within the field.

There is a recognizable global movement noticeable towards the popularity of fermented foods as well a clear statement by the scientific, clinical community publishing findings on the health benefits of the consumption of raw fermented foods, combined with a growth of dietary-related diseases in the Netherlands. This combination implies a potential causality between the potential of health benefits of lacto-fermented food and lowering the number of diseases within the Netherlands, which will be assessed in this report.

1.5 Research question and main objective

As argued in the previous paragraph’s food is amongst the most vital parts of human health. In order to support the health of the population, governments release dietary recommendations based on the latest scientific findings of how to maintain a healthy diet. When countries are affected by diet-related diseases, like the Netherlands, it is obvious that dietary recommendations are an important tool to counteract negative developments. In the Netherlands, the most relevant diet-related diseases include cardiovascular diseases and inflammatory bowel syndrome. As argued in paragraph 1.4 the latest findings on the consumption of raw lacto-fermented vegetables indicate a positive relationship between the prevention and treatment of those diet-related diseases. Still, those findings on the health benefits of including raw lacto-fermented vegetables into the daily diet, regarding cardiovascular diseases and inflammatory bowel syndrome, are unknown to the Dutch government and the general public.

This leads to the following research question:

What are the health-related benefits of including raw lacto-fermented vegetables into the daily diet of the Dutch population in regards to preventing and treating cardiovascular diseases and inflammatory bowel syndrome?

Resulting from that the following sub-questions are going to contribute to the answer to the main research question:

1. What are raw lacto-fermented vegetables?
2. What is known in the literature about the impact of raw lacto-fermented vegetables on health in general?
3. What is known in the literature about the impact of raw lacto-fermented vegetables on cardiovascular diseases?
4. What is known in the literature about the impact of raw lacto-fermented vegetables on IBS?

The objective of this thesis is to gain insight into the crucial role of raw fermented vegetables to prevent and treat cardiovascular diseases and inflammatory bowel syndrome in the Netherlands. This is because the positive effects of consuming raw lacto-fermented vegetables, which has been proven by scientific findings, are widely unknown to the Netherlands, it's public, and the government.

The importance of a functioning health care system to the economy, the governments, and the overall population is inevitable. This report will aim to focus on illustrating the health bringing benefits concerning cardiovascular diseases and inflammatory bowel syndrome to the overall Dutch population and the government. Therefore, the main target group is Dutch individuals. The scope will be limited solely to the health bringing benefits of raw lacto-fermented vegetables regarding cardiovascular diseases and inflammatory bowel syndrome as the assessment of the overall effectiveness of food recommendations, in general, would exceed the capacity of this report. Thus, this report intends to give a clear proposal for the addition of raw lacto-fermented vegetables into the diets of the Dutch population to reduce the risk and smaller the symptoms of two selected diseases. Those diseases include cardiovascular disease as well as inflammatory bowel syndrome as those are related to dietary behaviour and show great response to the compounds that are present in raw lacto-fermented vegetables, which will be argued and elaborated in the result sections.

2. Material and Methods

2.1 Research design

In order, to validate and answer the research question appropriately, the analysis of numerous and the most influential papers, see “selection criteria” in paragraph 2.2, has been analyzed in literature research.

As there is a vast number of acknowledged studies concluding the health benefits and implications on all different kinds of diseases, literature research provides the potential to put these findings into perspective and make a clear statement for the application of them. Literature reviews are especially suitable when there is a firm foundation of scientific findings that can lead to a new assumption that is interdisciplinary and to show evidence of this statement on a meta-level (Snyder, 2019). This is specifically the case in this thesis because this paper aimed to provide an interdisciplinary statement crossing from governmental interest to clinical findings and its application.

The search machines ‘Google Scholar’, ‘Science direct’ ‘Elsevier’ and ‘PubMed’ ‘Oxford Academic’ have been utilized. This also has been applicable in order to draw the picture of the current association with health benefits and a positive impact of the consumption of raw lacto-fermented vegetables concerning cardiovascular diseases and IBD.

2.2 Selection Criteria

In order to determine the quality of the information used, the following criteria has been applied to determine whether a reference would have been used. Those criteria were based on the recommendations by “Hippokratia”, which is an internationally acknowledged medical research journal. Specifically, the recommended selection criteria in their publication “meta-analysis in medical research” have been utilized in regard to finding references for the health bringing benefits of the consumption of raw lacto-fermented vegetables (Hippokratia, 2010). Next to this information published by acknowledged international and governmental bodies have been taken into consideration. Thus, the following selection criteria to determine valid references for this thesis were defined.

The criteria were:

- Not older than 10 years, always going for the most up to date version

- Articles from scientific journals
- Papers from official governmental sources like WHO, FAO and the ministry of health and agriculture
- Medical papers backed up by medical universities, so recognized research institutions
- Essays and reports with multiple authors
- Sources deducted from the bibliographies of relevant scientific articles
- Meta-analyses

(Hippokratia, 2010)

Furthermore, all references that suggest major statements that are relevant for the argumentation line were all checked for importance, prestige and scientific foundation by the Scimago Journal Rank Indicator (SJRI), which is an acknowledged online platform, using analytic measurements to determine the number of citations of an article also the relevance for different countries as well as a division in yearly citations and the so-called “SJRI (Scimago Journal Rank) indicator” (Scimago, 2020). The SJRI indicates the prestige and number of weighted citations of an article. All relevant references that are applicable for this paper had to have a ranking above 1.1 of the Scimago Journal Rank Indicator which is a baseline to indicate an article with high prestige and acknowledgment within the scientific community, determined by SJRI (Scimago, 2020).

2.3 Research method according to the sub-questions

All search words show a succession of more definitions of the previous search words, going from broad to detailed. The search words contributed to answering the sub-questions.

2.3.1 Sub-question 1: What are raw lacto-fermented vegetables?

Acknowledged research concerning this topic have been analysed, historical sources as well as the book “the art of fermentation” by Sandor Katz published in 2012, which is, up to date, the most relevant collection of information. Relevant search words included

“fermented foods”, “history fermentation”, “fermentation global food culture”, “lacto-fermentation”, “lacto-fermented vegetables”, “raw lacto-fermented vegetables”, “raw versus cooked fermented vegetables”

2.3.2 Sub question 2: What is known in the literature about the impact of raw lacto-fermented vegetables on health in general?

In order to find the most relevant results, papers published and backed up by official medical institutions and experts within the field, also quotes have been searched to underpin certain statements. According to that the search words included:

“health benefits of fermented vegetables”, “probiotics in lacto-fermented vegetables”, “consumption of fermented vegetables”, “nutrition fermented vegetables”, “probiotics fermented vegetables”, “gut health fermented vegetables”, “fermented foods and disease prevention”

2.3.3 Sub question 3: What is known in the literature about the impact of raw lacto-fermented vegetables on cardiovascular diseases?

Information to answer this sub-question has been backed by clinical statements and reports and deducted from official sources like medical universities, clinical publications of relevance, and statements by acknowledged personalities within this field. Thus, the search words included:

“cardiovascular diseases and nutrition “, “cardiovascular disease”, “prevention cardiovascular disease”, “fermented foods and cardiovascular diseases”, “preventive effect of consumption of fermented vegetables on cardiovascular diseases”, “fermented vegetables and cholesterol”

2.3.4 Sub-question 4: What is known in the literature about the impact of raw lacto-fermented vegetables on IBS?

The answers to this sub-question have been scientifically proven by clinical statements and reports and deducted from official sources like medical universities, clinical publications of relevance, and statements by acknowledged personalities within this field. Thus, the search words included:

*“Inflammatory bowel disease”, “succession inflammatory bowel disease “,
“inflammatory bowel disease nutrition”, “inflammatory bowel disease statistics”,
“inflammatory bowel disease prevention”, “inflammatory bowel disease and dietary
recommendations”, “probiotics and inflammatory bowel disease”, “fermented foods
and inflammatory bowel disease”,*

2.4 Literature analysis

While this research focused on providing a statement based on meta-analytic literature research, there has been a regime on how the literature will be analysed.

After assessing the prestige and relevance of a publication or any other reference, the key findings have been extracted. This happened by concluding the main objectives from the “abstract” section of a paper for example and the main findings of the “conclusion” section of a paper.

3. Results

The following chapter will provide an answer to the main research question by giving a broad introduction to raw lacto-fermented vegetables, its universal health benefits, and connect those to cardiovascular diseases as well as IBS. The vast amount of scientific research on the topic of lacto-fermentation and the latest increase of research concerning the health bringing effects of the consumption of lacto-fermented vegetables arose the expectation that there is also a correlation between the consumption of lacto-fermented vegetables and cardiovascular disease and IBS, which will be presented in the following paragraphs.

3.1 What are raw lacto-fermented vegetables?

First and foremost, it is inevitable to understand what raw lacto-fermented vegetables are in order to gain a basic understanding of why there might be a potential for the Dutch population to treat and prevent IBS and cardio-vascular diseases.

The word “lacto-fermentation” derives from the main active bacteria which are lactic-acid producing lactobacilli, LAB’s in short (Katz, 2012). Whereas the word “raw” indicates that the lacto-fermented vegetables have not been heat-treated above 60°C, as LAB’s are no longer active above this mark (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019). Lacto-fermentation falls under the overall preservation technique of fermentation. Fermentation means the transformative action of microorganisms. For lacto-fermentation, it is the transformative action of lactobacilli into organic acids, like lactate, propionate, butyrate and acetate as well as hydrogen dioxide, carbon dioxide, diacetyl, and acetaldehyde (Ray & Joshi, 2014). The process of fermentation is facilitated by the manipulation of the environment, by the exclusion of oxygen by forming a so-called “water-log”, which allows gases to release but no oxygen to enter. Furthermore, the addition of 1,5% - 2% of salt, of the total mass of fermented goods in dry-salting, or 5%-10% of saltwater brine (Katz, 2012), form an alkaline medium, illustrated in picture 1 below (Ecchlebowski, 2019).



Picture 1 Lacto-ferments, (Ecchlebowski, 2019)

This is necessary to create an environment favourable for the multiplication of desirable LAB's and the restrictive growth of pathogenic microorganisms (FAO, 2017). Those include fungi, salmonella, e-coli, clostridia and listeria. Methods, equipment and ratios differ from culture as well as particular climatic conditions around the world (FAO, 2017).

The key element to this natural process is either the natural resident microflora, meaning the LAB's present on the vegetables, or the inclusion of a so-called starter culture, defined as the microbial isolated large number of cells of single or a mixture of microorganisms (Swain & Ray, 2017). The ability to discern these preservation techniques and its health bringing- and sustaining benefits continue to be lost within our modern culture (Katz, 2012). Due to modern preservation techniques like refrigeration, pasteurization, sterilization, freezing, chemical shelf life enhancers, and an assortment of all foods and beverages around the world, have made the use of lacto-fermentation as a preservation technique redundant (Katz, 2012). Nevertheless, although the understanding of fermentation processes was mainly established on a base of intuition, trial and error and culturally embedded recipes, science has picked up analysing fermented foods also for their nutritional properties, with incredible results (Katz, 2012)

3.2 What is known in the literature about the impact of raw lacto-fermented vegetables on health in general?

Science is slowly picking up on the overall effect on gut health and the close relationship between overall physical health and the consumption of lacto-fermented foods, with lactic

acid bacteria being amongst the most studied microorganisms (Şanlıer, Gökçen & Sezgin, 2019). Thus, implicating the potential that lacto-fermented vegetables might be a functional food that offer a reduction in the number of people in the Netherlands that suffer from cardiovascular diseases and IBS. In order to validate this expectation, the following paragraph describes the general health effects of the consumption of lacto-fermented vegetables. Scientific results identify lacto-fermenting as a preservation and sometimes even enhancement of the nutritional benefits of fruits and vegetables over a long time, as a source of pre- and probiotics, being an influence on cholesterol, anti-fungal, anti-inflammatory, anti-allergic, anti-diabetic and a source of fibre, as well as producing biologically active peptides like proteinase and peptidase (Şanlıer, Gökçen & Sezgin, 2019). This includes conjugated linoleic acids (CLA), which is associated with lowering blood pressure, exopolysaccharides exhibit prebiotic properties, or sphingolipids which are labelled as anti-carcinogenic, just to name a few (Şanlıer, Gökçen & Sezgin, 2019). Most papers found during this research dealt with two main topics in relation to lacto-fermented foods. The first is food preservation and food security, which is mainly mentioned when talking about establishing food autonomy, whereas the focus lies on the preservation of nutrients and the availability of those. Secondly, most papers talk about the relationship between the regular consumption of lacto-fermented vegetables and gastrointestinal health. Therefore, those two aspects and its findings will shortly be introduced.

3.2.1 Food preservation and food security

Predominantly lacto-fermentation is associated with food preservation, food security, and palatability before the evolution of modern preservation technique in the west (Ray & Joshi, 2014). While it is still essential in under-developed and developing countries (FAO, 2017). Additionally to lowering the pH and the high salt concentration which creates an unfavourable environment for foodborne pathogens, many strains of lactobacilli present in lacto-fermented vegetables are found to have an antagonistic effect towards the most common pathogens like salmonella, monocytogenes, listeria, bifidobacteria coli staphylococcus aureus as well as mucus cells (Ray & Joshi, 2014). Thus, promoting the availability of food safe sources of nutrients without the need for artificial shelf life enhancers, refrigeration, freezing, drying

or other energy intensive food storages (Katz, 2012). See an example of lacto-fermented vegetables in so called “crock pots” in the Indian Himalaya in picture 2 below (Nehal, 2013).



Picture 2, Lacto-fermentation in developing countries, (Nehal, 2013)

Next to that, lacto-fermentation inhabits the capability to preserve nutrients over a long period of time with the benefit of being low in calories, with around 25kcal per 100g, containing no registered allergens and high amounts of essential minerals, vitamins and dietary fibres (Nutritionalvalues.org, 2020). Next to that the vitamin preservation, in particular vitamin C and K as well as increasing iron bioavailability (Ray & Joshi, 2014). In an extensive report “health benefits of fermented foods”, published by the University of Health Science in Istanbul, lacto-fermentation, in particular, has proven to be capable of enhancing vitamin C, K and B12 contents by multiple factors (Şanlier, Gökçen & Sezgin, 2019). Furthermore, most strains of the LAB’s namely lactobacillus, leuconostoc and pediococcus possess the capacity to transform anti-nutritional compounds in foods during fermentation into edible compounds. For example, the two toxic compounds linamarin and lotaustralin present in cassava root, which is a staple food in many developing countries, are no longer present after lacto-fermentation (Ray & Joshi, 2014).

3.2.2 The influence of lacto-fermented vegetables on the digestive system

Another important finding is the pro- and prebiotic effect of regularly consuming lacto-fermented vegetables. The term “probiotic” is defined by the WHO as “live microorganisms which, when administered in adequate amounts, confer a health benefit on the host” (Chilton, Burton & Reid, 2015). The human microbiome in the digestive tract contains 10¹³–

1014 types of microorganisms that are significantly involved in the state of human health. Additionally, the term accounts for several food groups that include live bacteria that directly translate into the gastrointestinal tract and show the same health bringing effect (Ray Ray, El Sheikh & Sashikumar, 2014). Those bacteria include lactobacilli, bifidobacterial, and enterococci, which are all present in lacto-fermented vegetables (Agrawal, 2015). Especially lactobacillus and bifidobacterium are labeled probiotics and provide the benefits as long as consumed without a heat treatment above 60°C (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019) as well as regularly and plenty (Swain & Ray, 2014). Furthermore, exopolysaccharides in lacto-fermented vegetables exhibit prebiotic properties (Ray and Joshi, 2014), whereas prebiotic is defined as “a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improves host health” (Davani-Davari et al., 2019). Those pre-probiotic effects of compounds that are derived from lacto-fermentation also proved to be highly effective against high serum-cholesterol levels, which will be elaborated in the following paragraph (Kumar et al., 2012). Although various medical supplements advertise probiotic effects, an intensive analysis by Viktoria Yonkova Marinova et.al showed, that out of 890 commercially available probiotic strains only 420 met the criteria of LAB (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019). Whereas, in for example 100g of the lacto-fermented vegetable dish “kimchi”, likewise other lacto-fermented cabbage dishes, provides 10^{10} live organisms and thereby fulfils the requirements to positively alter the gut microbiota and provide a health benefit (Derrien & van Hylckama Vlieg, 2015). Furthermore, LAB's encourage several digestive processes as they contain digestive enzymes like α -amylase, proteinase, and pectinase which help and boost the digestive system (Panda & Ray, 2016). For example, during the fermentation process, proteinase digest vegetable proteins and indigestible Sulphur compounds, in this manner it improves the digestibility of for example of garlic and onions (Di Cagno, Coda, De Angelis & Gobbetti, 2013)

3.3 What is known in the literature about the impact of raw lacto-fermented vegetables on cardiovascular diseases?

In order to provide an answer to the main research question, it is important to understand the causes of cardiovascular diseases, so the relation between lacto-fermented vegetables

and the treatment and prevention is clear. Therefore, the following paragraph will present the source of cardiovascular diseases.

3.3.1 The source of cardiovascular diseases

Concerning the prognosis of the WHO, by 2030 cardiovascular diseases will remain to be amongst the leading causes of death, affecting around 23,6 million individuals across the globe (WHO,2019). In the Netherlands, it remains to be the biggest cause of deaths caused by diseases (European Commission, 2019). Around 45% of cases of heart attacks in Western Europe are contributed by hypercholesterolemia, meaning the excessive presence of cholesterol in the blood serum of patients, as well as 35% of heart attacks in Central and Eastern Europe, indicating that the risk for heart attacks is three times higher when exposed to hypercholesterolemia (Yusuf, Hawken & Ôunpuu, 2014). In a paper published by the WHO, it is stated that unhealthy diets that include high amounts of fats, salt, free sugars and low in vegetables, fruits and complex carbohydrates lead to an increased risk in cardiovascular diseases, mainly due to strong exposure to cholesterol (WHO, 2014). Current methods of prevention and treatment include dietary management and recommendations for low-fat diets as well as drug therapy (Kumar et al., 2012). However currently available drugs appear to be expensive and are known to come with severe side effects (Bliznakov, 2012). Besides, the recommendation for an extremely low-fat diet that offers an effective reduction in blood cholesterol levels, appear to be ineffective due to low palatability, acceptability by the consumer and poor compliance (Kumar et al., 2012). Therefore, the search for low-cost, low-risk food compounds that contribute to lower cholesterol levels has brought science into the direction of pro-and prebiotics in naturally unpasteurized ferments of all kinds (Kumar et al, 2012).

3.3.2 The potential of pro-prebiotics to prevent cardiovascular diseases

In a report called “potential of probiotics in controlling cardiovascular diseases” by Rajiv Saini in 2010, it is concluded that the probiotics contained within raw lacto-ferments are capable of reducing blood cholesterol in three main ways. Firstly, by countering cholesterol production, secondly by breaking down bile acids which are derived from blood cholesterol,

thus reducing the amount circulating and thirdly by being capable of using cholesterol as an energy resource by directly breaking down blood cholesterol. Thus, reducing the main cause of cardiovascular diseases to occur (Saini, Saini, & Sharma, 2010). Nevertheless, it is important to mention that alive pro-prebiotic strains have to exceed the number of 10^8 – 10^9 CFU mL⁻¹ at the point of consumption to be beneficial, which usually is the case for all naturally fermented lacto-fermented vegetables. This is because only this amount of alive pro-prebiotics are capable of surviving the digestive tract to have a beneficial effect on the host C (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019). Therefore it is important to mention that most pro-prebiotic strains are not heat resistant and therefore are no longer active after their internal temperature has exceeded 60°C (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019).

3.4 What is known in the literature about the impact of raw lacto-fermented vegetables on IBS?

As for the previous paragraph, it is important to understand the cause of IBS in order to identify the relation between IBS and the consumption of lacto-fermented vegetables, thus being able to answer the main research question.

Inflammatory bowel syndrome (IBS) is the medical term for the chronic inflammation of the lower gut and colon, illustrated in picture 3 below (Divya, Varsha, Nampoothiri, Ismail, & Pandey, 2012).



Picture 3, Inflammatory bowel syndrome, (UltraDD, 2019)

Clinical symptoms of IBS include diarrhoea, weight loss, fatigue, abdominal discomfort, and even rectal bleeding. Untreated IBS can develop into ulcerative colitis or even Crohn's disease which can be fatal (Spekhorst et al., 2017).

Every fourth individual in the Netherlands is affected by inflammatory bowel syndrome concerning the Dutch IBD Biobank, established by all influential medical universities in the Netherlands (Spekhorst et al., 2017). IBS is mainly caused by diet-related factors as well as antibiotic prescriptions and can be reinforced or treated by regulating the patient's diet (Portincasa, 2017). Therefore, a focus on finding functional food groups that treat and prevent IBS and answering the question of what the health benefits of consuming lacto-fermented vegetables to the disease are is of strong importance (Spekhorst et al., 2017).

Within the course of the past ten years, science has proven a strong relationship between the health beneficial effects of the consumption of raw lacto-fermented vegetables, especially in IBS and cardio-vascular diseases (WHO, 2017). The main factor for therapeutic treatments is the restoration of an altered microbiota in the gastro-intestinal tract. According to the meta-analysis concerning IBS by Jayakumar Beena Divya et.al. the most ideal treatment to restore the intestinal microbiota and treat IBS is the consumption of probiotics (Divya, Varsha, Nampoothiri, Ismail, & Pandey, 2012). The results also identified increased amounts of mucosal bacteria including *E. coli*, Enterococci as well as bifidobacteria as most effective in reducing symptoms and restoring the microbiota in all clinical participants. For example, children with mid-to moderate Crohn's disease that were treated with bifidobacteria and lactobacilli twice a day for six months showed a reduction of colonic mucosal secretion of mucin and fluids that are the main cause of diarrhoea below (Divya, Varsha, Nampoothiri, Ismail, & Pandey, 2012).

Enterococci, bifidobacteria as well as a high number of lactobacilli are found in lacto-fermented vegetables (Agrawal, 2015). The daily consumption of lacto-fermented vegetables suggests a relief in the symptoms as well as bring a preventive effect for inflammatory bowel syndrome mainly due to the numerous pre-probiotic bacterial strains (Swidsinski, 2012).

Although there are several isolated probiotic supplements available on the market, they are putting a financial burden on society as they are not covered by insurance. Furthermore, there is scientific proof of the low number of live LAB, thus the low effectiveness of those supplements (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019).

Therefore, raw lacto-fermented vegetables present an economically sustainable alternative, allowing individuals to produce their probiotic foods themselves with seasonal, regional low-cost vegetables and sea salt (Katz, 2012). The only requirement is the knowledge on how to perform a lacto-fermentation and the preparation. Generally, this knowledge is lost due to modern preservation techniques that made fermentation redundant (Katz, 2012).

Although there is a lacto-fermented food embedded and widely commercially available in the Netherlands, the so-called “zuurkool”, a fermented cabbage dish, it is mostly pasteurized, thus without any pro-prebiotic effect (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019), see in picture 4 below (Okoko, 2020).



Picture 4, Zuurkool (Okoko, 2020)

4. Discussion of results

The objective of this thesis was to gain insight into the relation of lacto-fermented vegetables and the prevention or treatment of cardiovascular diseases and IBS in the Netherlands. Although the Netherlands is amongst the countries with the highest investments into health care, numbers of cases of cardiovascular diseases and IBS are continuously rising (European Commission, 2019). Recently science has intensively picked up on researching the potential health-bringing benefits of the consumption of lacto-fermented vegetables, also indicating a relation with the two diseases. The results of this research will be discussed in the following paragraphs.

4.1 What are raw lacto-fermented vegetables?

Raw lacto-fermented vegetables are products of lacto-fermentation, which means the transformative action of microorganisms, mainly LAB's, converting fibres and sugars into organic acids, including lactic-acid and gases, along carbon dioxide (Katz, 2012). Lacto-fermentation falls under the category of fermentation, which in culinary terms is the oldest preservation technique known to humankind, preserving nutrient over a long time, while creating an environment unfavourable for food borne pathogens (Ray & Joshi, 2014).

The process of fermentation and lacto-fermentation has been intensively scientifically analysed, defined and standardized. The extensive findings around this sub-question were non-contradictory and described lacto-fermentation and lacto-fermented vegetables in a uniformly manner with different degrees of depth. Thus, the answer to this sub question could clearly been given. The results could be transmitted to the target group in order to help gaining a basic understanding of lacto-fermented vegetables.

4.2 What is known in the literature about the impact of raw lacto-fermented vegetables on health in general?

Two main topics were identified while analysing data concerning the health-bringing benefits of lacto-fermented vegetables. First, the nutritional aspect and the possibility to preserve and even enhance nutrients over a long period of time, without any artificial shelf life enhancers nor extensive use of energy, which falls under the category of food security and preservation (Ray & Joshi, 2014). Second, the influence of regularly consuming lacto-fermented vegetables

and gastrointestinal health, mainly due to the extensive pro-prebiotic content in the ferments (Ray & Joshi, 2014). The pro-and prebiotics within lacto-fermented vegetables are capable of restoring the live bacteria that directly translate into the gastrointestinal tract and show health bringing effect, like for example lowering blood serum cholesterol (Ray, El Sheikha & Sashikumar, 2014). Just like in 4.1 there was a great number of scientific proofs to be found concerning the health-related benefits of the consumption of lacto-fermented vegetables in relation to bioavailability of nutrients and pre- and probiotics. Extensive scientific research published by the FAO and Ray, R.C., A.F. El Sheikha and R. Sashikumar as well as R.C. Ray and V.K Joshi., have been taken into consideration while answering this sub-question. Especially the pro-prebiotic effect of lacto-fermented vegetables have gained interest over the past decade and therefore been the topic of the latest publication circling around gut-health. Thus, the results were sufficiently answer this sub question in a professional manner and could be transmitted as knowledge to the target group to create an important base for answering the main research question.

4.3 What is known in the literature about the impact of raw lacto-fermented vegetables on cardiovascular diseases ?

After analysing numerous results of renowned studies and publications it is clear that there is a direct relation between the prevention of cardiovascular diseases and the consumption of pro-prebiotics, especially due to the reduction of serum cholesterol, which is the main cause of the fatal disease (Saini, Saini, & Sharma, 2010).

Unlike for the two first sub-questions, the consumption of pro-prebiotics and the relation with serum-cholesterol have just recently gained more popularity, therefore scientific papers are fewer. Nevertheless, the expected result of finding a positive relation between the consumption of lacto-fermented vegetables and cardiovascular diseases were met, with stronger arguments than expected. Other than a small anticipated effect, medical research showed a strong evidence for a dramatic reduction of serum-cholesterol in patients that regularly consumed pro-prebiotics found in lacto-fermented vegetables (Saini, Saini, & Sharma, 2010).

4.4 What is known in the literature about the impact of raw lacto-fermented vegetables on IBS?

The pro-prebiotics within lacto-fermented vegetables have also been found to have a positive implication on the symptoms and a prevention of IBS. Due to the restoration of an altered microbiota in the gastro-intestinal tract, symptoms of clients that regularly consumed pro-prebiotics (Divya, Varsha, Nampoothiri, Ismail, & Pandey, 2012). Nevertheless there was only one paper to be found, using lacto-fermented vegetables as the specific source of pro-prebiotics. This might be a result of the extensive use of isolated medicinal pro-prebiotics which were mostly subject to studies conducted with po-prebiotics. For lacto-fermented vegetables, there would be more research needed in order to proof the positive relation to IBS. A positive result for lacto-fermented vegetables can be expected when looking at the comparison between the effectiveness of isolated pro-prebiotics and those naturally present in lacto-fermented vegetables (Marinova, Rasheva, Kizheva, Dermenzhieva, & Hristova, 2019).

The general conclusion is that the results have met the expectations of the theory and even exceeded the extent to which a positive relation between the consumption of lacto-fermented vegetables and cardiovascular disease has been anticipated. There was extensive research to be found to answer the sub-questions and to come to a clear conclusion. Nevertheless, there has been little evidence for lacto-fermented vegetables as the specific source of pro-prebiotics when it comes to the treatment and prevention of IBS, therefore more studies towards this topic are necessary. Still the results can be transmitted to the target-group with confidence. The results can function as a baseline for recommendations which will be presented in the following chapter.

5. Conclusions and recommendations

Although the Netherlands is ranking relatively high when it comes to the effectiveness of its health-care system, the country still remains with rising numbers in two of the most common diet-related diseases amongst its population, including cardiovascular diseases and inflammatory bowel syndrome (IBS). The search for a cheap and effective functional food brought up the question whether there is a relation between the consumption of lacto-fermented vegetables and cardiovascular diseases and IBS. Over the course of the past decade, science showed interest analysing the health-bringing benefits of the consumption of lacto-fermented foods. Lacto-fermentation describes the transformative action of microorganisms, including lactobacilli (LAB), converting sugars and fibres present in vegetables into lactic-acid and mainly CO₂ (Katz, 2012). In this process it preserves the naturally present micronutrients and vitamins over a long period of time without the excessive use of artificial preservatives or the use of energy. Next to this lacto-fermented vegetable contain significant amounts of pro-prebiotics which directly translate into the microbiome of the human gut, thus providing numerous health-benefits when consumed regularly and without the application of heat above 60°C (Kumar et al., 2012). Cardiovascular diseases are mainly caused by an excessive amount of cholesterol present in the blood serum. Numerous studies have shown that the pro-prebiotics present in lacto-fermented vegetables can be associated with a significant reduction of cholesterol, mainly due to the pro-prebiotics metabolising it, therefore, eliminating the main cause of the diseases when consumed daily. (Saini, Saini, & Sharma, 2010). The pro-prebiotics are also responsible for a prevention of IBS and a treatment of the symptoms. This is because of the restorative effect on the gastrointestinal microflora and therefore strengthening the resilience towards an inflammation of the gut, resulting in IBS (Divya, Varsha, Nampoothiri, Ismail, & Pandey, 2012). There are few studies researching the effect of regularly consuming lacto-fermented vegetables as the main source of pre-probiotics. Nevertheless, the strains of synthetic LAB's that have been given to patients that showed positive results, are also significantly present in the ferments. Thus, the answer to the main research question:

” What are the health-related benefits of including raw lacto-fermented vegetables into the daily diet of the Dutch population in regards to preventing and treating cardiovascular diseases and inflammatory bowel syndrome? “,

is that raw lacto-fermented vegetables are highly relevant in the prevention of cardiovascular diseases with the addition to soften the symptoms of IBS, mainly due to their high content in life pro-prebiotics, when consumed on a daily basis without the application of heat exceeding 60°C.

5.1 Recommendations

5.1.1 Inclusion of raw fermented vegetables into dietary recommendations

First and foremost, it is important to mention that there have been few results when it comes to the use of specifically lacto-ferments as the source of pro-prebiotics and the treatment of IBS. The specific strains that have been tested isolated on patients with IBS and Crohn’s diseases have been the same that are excessively present in lacto-ferments. Thus, a long-term is the recommendation of conducting further studies including patients with IBS and the effects of daily consumption of lacto-ferments and the effects on the succession of the diseases.

How can the Dutch population profit from lacto-fermented vegetables? Most publications that have been used to support the conclusions of this report are recommending to include the consumption of fermented foods into dietary guides and even fill extensive reports like the “inclusion of fermented foods in food guides around the world “ published by the leading authorities of the University of Western Ontario (Chilton et al., 2015). Also, because isolated pro-prebiotics in medical pills have shown to not meet requirements, as well as putting a financial burden on the consumer as most of the available isolated pro-prebiotics are expensive and not covered by insurances (Kumar et al., 2012). Therefore lacto-fermented vegetables can provide an inexpensive addition and alternative as they solely require commodity ingredients, time and knowledge to be produced autonomically, thus delivering an important solution for low income, resource challenged individuals that are affected by

cardiovascular diseases and inflammatory bowel syndrome (Kort et.al., 2015). This especially accounts for the Netherlands as 80% of the medical investments are publicly funded, like mentioned in the first chapter (European Commission, 2019).

A current challenges to this inclusion include a potential neophobic reaction to unfamiliar foods which is resulting from a loss of sufficient background information about the foods and a dislike of the unfamiliar flavour profile (Xiang et al., 2019). Furthermore, a general loss of knowledge on how to conduct lacto-fermentation and prepare the finished product is a major issue in western consumers (Katz, 2012). Therefore, education and dietary recommendations are the keys to utilize the health-bringing benefits of raw lacto-fermented vegetables, eventually having a positive impact on the numbers of Dutch citizens being affected by cardiovascular diseases and inflammatory bowel syndrome (Rezac et al., 2018). For example, Fernandes et al. explicitly advocate the daily consumption of fermented vegetables to children early in life in order to strengthen the diversity of the gut microbiome to increase the resilience towards a vast amount of fatal diseases including IBS and cardio-vascular diseases (Fernandes et al., 2018). This recommendation is also explicitly interesting for resource-challenged communities that are disproportionally affected by gastrointestinal infections, due to unproblematic and inexpensive accessibility of fermented foods (Kort et al., 2015).

5.1.2 Inclusion of raw lacto-fermented vegetables into the Wheel of Five

A potential platform for the Netherlands would be the inclusion into the dietary recommendations published by the Voedingscentrum, the so-called “Wheel of Five” as a short-term application of the results of this study (Voedingscentrum, 2017). The Dutch dietary guideline is also the base of the “Wheel of Five Guidelines” which is structured in terms of food groups and concludes a daily regime. It is simplifying and visualizing those recommendations and is meant for the related public information materials (RIVM, 2017). The recommendations illustrate the diet of a grown Dutch adult. See the infographic in the “Wheel of Five” in picture 5, which concludes the guidelines visually (Voedingscentrum, 2017).



Picture 5 “Wheel of Five Guidelines”, (Voedingscentrum, 2017)

The information is intended for the general population but is also used by professionals, health providers, and nutritionists for public education and again is intended to increase the overall health of the Dutch population (FAO, 2019).

The information is regularly updated by the Health Council of the Netherlands’ Standing Committee on Public Health and Standing Committee on Health Care, deriving the information from the Netherlands Nutrition Centre and the National Institute of Public Health and the Environment. This implies the inclusion of new food groups as soon as there would be a recognizable benefit for the Dutch population. This report can encourage the inclusion of lacto-fermented vegetables into the next updated version of the Wheel of Five (Voedingscentrum, 2017).

When questioning the relevance of suggesting lacto-fermented vegetables as a potential preventive functional food, it is important to ask whether the Dutch consumers are already familiar with the food group in order to simplify a potential inclusion into their diet plan.

Every culture inhabits several fermented foods (Katz, 2012). So does the Netherlands. The most traditional recipes that are geographically and culturally connected to the Netherlands include “zuurkool” a lacto-fermented dish consisting of white cabbage, sea salt, and bay leaves. Historically zuurkool has gained its reputation mostly due to the portability of vitamin

C that is built and preserved through lacto-fermentation (Kramer, 2018). Still today, zuurkool is culturally embedded into the Dutch culture and is traditionally consumed in the autumn and winter times (Kramer, 2018).

This means the Dutch culture inhabits a dish that could potentially be a solution to two of their most critical diseases. So, the question is why is the Dutch population not profiting yet from the health-bringing benefits of their culturally embedded dish?

There are two main reasons for this cause. The first one is the handling of the main companies producing and commercializing zuurkool. Due to easier handling and controlling, zuurkool mostly is pasteurized, which eliminates the vital nutrients and pro-prebiotics. Secondly, zuurkool is traditionally consumed in a dish called “Stampod”, a mixture of cooked potatoes and cooked zuurkool, which again eliminates the vital nutrients in the raw version.

This means that it is important to educate the Dutch population on how to prepare and consume lacto-fermented vegetables, to profit from the health bringing traits in the long term. Further publications on how to carry out lacto-fermentation to enable Dutch citizens to produce their pro-prebiotics and eventually treat symptoms and prevent IBS and cardiovascular diseases themselves, are necessary. Furthermore, potential substitutions for companies commercializing raw lacto-fermented local and seasonal vegetables could encourage the re-introduction of the functional food into the daily diet of the Dutch population.

The combination between scientific research, public education and commercial offerings of lacto-fermented vegetables could eventually help to lower numbers of patients with cardiovascular diseases and IBS in the Netherlands, in a cheap and effective manner.

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Appendices

Appendix 1

“Follow a dietary pattern that involves eating more plant-based and less animal-based food, as recommended in the guidelines.

- Eat at least 200 grams of vegetables and at least 200 grams of fruit daily.
- Eat at least 90 grams of brown bread, whole-meal bread or other whole grain products daily.
- Eat legumes weekly.
- Eat at least 15 grams of unsalted nuts daily.
- Take a few portions of dairy produce daily, including milk or yoghurt.
- Eat one serving of fish weekly, preferably oily fish.
- Drink three cups of tea daily.
- Replace refined cereal products by whole-grain products.
- Replace butter, hard margarines, and cooking fats by soft margarines, liquid cooking fats, and vegetable oils.
- Replace unfiltered coffee by filtered coffee.
- Limit the consumption of red meat, particularly processed meat.
- Minimize consumption of sugar-containing beverages.
- Don't drink alcohol or no more than one glass daily.
- Limit salt intake to 6 grams daily.
- Nutrient supplements are not needed, except for specific groups to which supplementation applies.” (Voedingscentrum, 2017)