Centre hospitalier universitaire vaudois

Swiss dietary recommendations: scientific background

Final report

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Pedro Marques-Vidal [1]; Esther Infanger [2]; Béatrice Baumer [3]; Klazine Van der Horst [4]; Undine Lehmann [4]; Nicole Bender [5]; Sarah Pannen [6]; Nena Karavasiloglou [6]; Sabine Rohrmann [6]; Yassmeen El Maohub [7]; Camilla Speranza [7]; Suzanne Suggs [7]; Martina Alig [8]; Carmen Sangin [9]; Sophie Frei [10]; Matthias Meier [11]

[1] Centre hospitalier universitaire vaudois CHUV, Lausanne; [2] Externas GmbH, Bern; [3] Zürcher Hochschule für Angewandte Wissenschaften ZHAW, School of Life Sciences and Facility Management; [4] Bern University of Applied Sciences BFH, Department of Health Professions, Bern; [5] University of Zürich, Institute of Evolutionary Medicine, Zürich; [6] University of Zürich, Epidemiology, Biostatistics and Prevention Institute, Zürich; [7] Università della Svizzera Italiana USI, Faculty of Communication, Culture and Society, Institute of Public Health, Lugano; [8] Intep - Integrale Plannung GmBH, Zürich; [9] Fourchette verte Suisse, Lausanne; [10] freistil - Ernährung und Bewegung, Bern; [11] Bern University of Applied Sciences BFH, School of Agricultural, Forest and Food Sciences HAFL, Food Science & Management

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List of abbreviations

ALA: alpha-linolenic acid
AMI: acute myocardial infarction
ASB: artificially sweetened beverages
BMI: body mass index
CCS: case control study
CHD: coronary heart disease
CI: confidence interval
DB: diet beverages
DHA: docosahexaenoic acid
EMR: evidence mapping review
EPA: eicosapentaenoic acid
EPIC: European Prospective Investigation Into Cancer
FCN: Federal Commission of Nutrition
FFQ: food-frequency-questionnaires
FSVO: Federal Food Safety and Veterinary Office
HCC: hepato-cell carcinoma
HR: hazard ratio
MA: Meta-Analysis
MUFA: monounsaturated fatty acids
NA: not available
n.s.: non-significant
NCD: non-communicable diseases
NR: narrative review
OR: odds ratio
PCS: prospective cohort studies
PUFA: polyunsaturated fatty acids
R: review
RCT: randomized controlled trial
RTEC: ready-to-eat (breakfast) cereals
RR: relative risk
SB: sweetened beverages
SFA: saturated fatty acids
SFCD: Swiss food composition database
SR: systematic review
SSB: sugar-sweetened beverages
T2D: type 2 diabetes
TFA: *trans* fatty acids
UPF: ultra-processed foods
UR: umbrella review
WC: waist circumference
WFLDB: World Food Life Cycle Database
WG: whole grain
WHO: World Health Organization

1 Introduction, context, objective

1.1 Introduction

Noncommunicable diseases (NCD) include cardiovascular disease, cancer, diabetes and obesity. They represent a major part of morbidity and mortality worldwide (1). In Switzerland, over 2 million people live with at least one NCD (2) and, in 2013, NCD represented 80% of total health costs in Switzerland (2). Importantly, the trend should increase due to the aging of the Swiss population. At the same time, environmental degradation is steadily increasing and our current way of life is overusing the resources available to us.

An unhealthy diet is the most important risk factor for NCD, accounting for 11 million deaths and 255 million disability-adjusted life-years worldwide (3). Our current global diet is also not compatible with living within the planetary carrying capacity (4, 5). National and international dietary guidelines have been issued, which provide guidance for healthy eating and prevention of NCD (see for instance (4-6)). In Switzerland, dietary guidelines have been issued (8, 9), and an update of the scientific evidence linking foods and NCD was published in 2019 (10). However, they do not contain information on the environmental impact of different food items.

1.2 Context

Provision of safe and nutritious food is paramount to prevent the occurrence of NCD and ensure that people will remain healthy, with adequate intake of macro and micronutrients. To ensure an adequate provision of healthy, tasty, and safe foods to the general population, food production systems must be optimized. Furthermore, food production takes its toll on the environment, and some dietary guidelines have been found to be either unsustainable or to deleteriously impact the environment (6, 7).). In order to achieve sustainable nutrition, both health and sustainability aspects should be considered and aligned. Sustainable nutrition recommendations must consider both aspects equally.

1.3 Objective

This report updates and extends the previous one published by the Federal Commission for Nutrition (FCN) in 2019 (10). It was decided not to merge both reports as information on several foods not included in the previous version is provided, as well as an appraisal of the ecological footprint of several food groups considered as important for the Swiss diet, and a commented review of the dietary guidelines of neighbour countries. The associations between each food group and the different NCD indicated above have been summarized in tables (the detailed search strategies can be found in the annex). For each food, the conclusions are presented based on two criteria: class and level of evidence, a procedure that has been used in other guidelines (11, 12), see **table 1** next page. For example, a conclusion classified as IA will have the highest evidence, while a recommendation classified as IIC indicates conflicting results and evidence. As in the 2019 report, the target population was healthy adults (aged 18+ years); younger people or specific conditions (i.e., pregnancy, lactation, and disease) were not considered.

This report has four main parts. The first one (chapter 2) assesses the associations between foods and four NCD: CVD, cancer, T2D and obesity. The second part (chapter 3) assesses the ecological footprint of the production of foods commonly consumed in Switzerland. The third part (chapter 4) compares the current Swiss dietary guidelines with those of neighbouring countries and major international organizations. The fourth part (chapter 5) lists the foodstuffs important for the Swiss nutritional guidelines.

This collaborative work is the task of researchers from all over Switzerland, who joined efforts to summarize a large body of literature and data for the updating of the Swiss dietary guidelines. The authors hope that their efforts will benefit the Swiss population and lead the path to a healthier, sustainable diet.

Table 1: Classes and evidence levels of the conclusion

Class	Definition
I	Evidence and/or general agreement that a given food is beneficial
II	Conflicting evidence and/or divergence of opinion about the benefits of the food
III	Evidence that the food, consumed in excessive amounts, is deleterious
Level	**Definition**
A	Data derived from multiple randomized controlled trials or meta-analyses
B	Data derived from a single randomized controlled trial or multiple prospective studies
C	Experts' agreement and/or retrospective or case-control studies

Adapted from (13).

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2 Link between diet and noncommunicable diseases

2.1 Water

Authors: L. Suzanne Suggs, Yasmenn El Maohub Reviewer: Undine Lehmann

2.1.1 *Introduction*

"Water of drinking quality is defined in the Swiss food legislation as either mineral water, i.e., microbiologically irreproachable water from underground layers or deposits and is extracted from a source accessible through one or more natural or artificial outlets, or as spring water. This is water of subterranean origin which is marketed while preserving its original state" (1). Safe drinking-water is considered to be essential to sustain life, resulting in benefits to health (2). The Swiss dietary guidelines recommend the consumption of 1-2 litres of unsweetened beverages per day (3). This can be consumed in various forms, such as tap water, mineral water, unsweetened herbal teas (3-4).

The 2019 FCN report (1) highlights that "water is increasingly being identified as playing a key role in chronic disease prevention (5, 6), in particular for chronic kidney disease (7, 8), nephrolithiasis (7), cardiovascular disease (9), obesity (10, 11) and type 2 diabetes (12). In this report, the focus was on updating the evidence of the relationship between non-communicable diseases (i.e., cardiovascular diseases, all types of cancer, diabetes, and obesity) and water consumption, including mineral water and green tea. Some findings regarding contaminated water have also been included as they appeared possibly relevant for Switzerland (e.g. nitrate from agriculture in drinking water).

2.1.2 *Search strategy*

We conducted a search strategy in the database PubMed and Cochrane, including "water" as the intervention and NCD as outcomes ("cancer", "cardiovascular system", "diabetes", etc.) formulated as MeSH terms, as free text, and as text in the title or abstract. We applied filters for human subjects, adult population, English language, publication years 2018-2021, and study design (review, systematic review, meta-analysis, RCT). The syntax is provided in the annex, chapter 2.1. We retrieved and included 11 full-text articles.

2.1.3 *Main findings*

2.1.3.1 Cardiovascular diseases

A meta-analysis and a RCT focused on the relationship between two different forms of water and cardiovascular health. The meta-analysis reported that daily consumption of high hydrogen water improved the endothelial function of arteries or arterioles (13). The RCT showed that regular consumption of green tea had cardiovascular protective effects, whereas hot water did not induce significant changes (14).

2.1.3.2 Cancer

Two meta-analysis and a RCT studied the association between contaminated water and the generation of different types of cancer. Except for the first study (15) which found a positive association between water nitrate and colorectal cancer risk, the other two showed no association between nitrate- and fluoride-contaminated tap water and carcinogenic risk (16, 17).

2.1.3.3 Diabetes

Two randomized-controlled trials and a meta-analysis of RCTs studied the effects of water/mineral water, alkaline water vs. neutral water and water vs. sucrose-sweetened beverages (SSB) on glycaemic parameters. The meta-analysis reported that results are heterogeneous, however that there is low evidence on water/mineral water to improve parameters in diabetic and non-diabetic persons (18).

Despite the evidence reported in the first RCT (14) showing a positive effect of alkaline water on diabetic parameters, the study found no association between pH-changed water and neutral water on glucose regulation. The second RCT reported a positive effect of water on post-drink plasma glucose on the contrary of sucrose-sweetened beverages (19).

2.1.3.4 Obesity

Three RCTs evaluated the effects of water vs. artificially sweetened beverages (ASB), water accompanied to food, and water vs. diet beverages (DB) respectively. Water intake compared to LCS beverages did not differ in the total energy intake (13). Drinking water during the consumption of a meal did increase blood glucose level causing chronic disorders such as obesity in contrast to consuming it 30 minutes before or after the meal (4). The third RCT revealed the positive effects of water on decreasing the BMI compared to DB (20).

2.1.4 Conclusion

There is a dearth of studies regarding the positive/negative effects of water on NCD. Furthermore, the interpretation of the findings depends on the specific study since the intervention studies dealt with contaminated water (e.g., nitrate in water) or a comparison of other types of beverages to water. Hence, a general trend cannot be drawn given the scarcity and the specificity of studies. Furthermore, no statements can be made about the recommended amount of water.

Table 2: Summary water intake and risk of NCD

Conclusion	**Class**	**Level**
High H_2 water and green tea consumption have protective effects on cardiovascular health	I	B
Nitrate and fluoride in water might be associated with cancer	II	A
Water, alkaline water, and mineral water do not seem to have positive effects on glycaemic parameters	II	B
Drinking water before or after the meal might be beneficial in weight reduction	I	B

2.1.5 Recommendations

As in the previous FCN report (22), we found very few studies on the effect of water or fluid intake on NCD. Besides the deleterious effect of nitrates, no minimum or maximum amounts could be obtained.

Table 3: Estimation of minimum, optimal, and maximum amount of water intake in relation to NCD

Food group	**NCD**	**Minimum**	**Maximum**	**Optimal**
High H_2 water	CVD	-	-	3.5 mg of H_2/500 mL/day
Green Tea	CVD	-	-	1 L/day
Water fluoride	Cancer	-	-	-
Water nitrate	Colorectal cancer	0	0	0
Water	T2D	-	-	-
Alkaline water	T2D	-	-	-
Mineral water	T2D	-	-	-

-, not reported.

Table 4: Results of the associations between water and other beverages and health outcomes

Ref.	Year	Study	Food type	Results	Grade
Cardiovascular disease					
(2)	2019	RCT	Green Tea vs hot water	Regular ingestion of green tea has cardiovascular protective effects.	IB
(21)	2020	RCT	Water with H_2	Daily consumption of high H_2 water improved the endothelial function of the arteries or arterioles.	IB
Cancer					
(17)	2018	RCT	Water nitrate	No association between nitrate in drinking water and pancreatic cancer risk.	IIB
(15)	2019	MA	Water nitrate	Significant positive association for drinking water containing nitrate and colorectal cancer risk.	IIIA
(16)	2019	MA/ SR	Water fluoride	No significant non-carcinogenic risk for consumers due to drinking water fluoride in Iran.	IIA
Diabetes					
(18)	2017	MA of RCTs	Water and mineral water	Low evidence for the positive effects of water or mineral water in improving glycaemic parameters in diabetic and non-diabetic persons. The results are heterogeneous, making it difficult to reach an unequivocal conclusion.	IIA
(14)	2018	RCT	Water vs. alkaline water	No differential effect of alkaline vs. neutral drinking water on the gut microbiota composition or glucose regulation and inflammatory state of healthy, male volunteers.	IIB
(19)	2019	RCT	Water vs. SSBs	Compared with water, consumption of sucrose-sweetened beverages significantly elevates post-drink plasma glucose in association with a sustained elevation in plasma insulin throughout a day of prolonged sitting.	IB
Obesity					
(13)	2018	RCT	Water vs. ASBs	Water and ASB did not differ in their effects on total energy intake.	IB

Ref.	Year	Study	Food type	Results	Grade
(4)	2018	RCT	Water	Drinking water with consumption of a jelly-filled doughnut increases the postprandial blood glucose levels significantly compared to no drinking at all or thirty minutes before or after the consumption.	IB
(20)	2018	RCT	Water vs. DBs	BMI decreased more in the water group than in the DBs group. Replacement of DBs with water after the main meal in women who were regular users of DBs may cause further weight reduction during a 12-month weight maintenance program.	IB

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review.

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2.2 Coffee

Authors: L. Suzanne Suggs, Camilla Speranza Reviewer: Beatrice Baumer

2.2.1 Introduction

Coffee beverage is made by infusing or percolating water with roasted and ground beans from the *Coffea* plant (1). The association between coffee and different health outcomes is not uniform. This is likely because research on coffee was historically done from a toxicological point of view, hence the focus on a hypothesis linking high dosage to negative outcomes. More recent studies have shifted the perspective of consumption of coffee and potential benefits. The previous FCN report indicated that, for adult male and non-pregnant women, drinking up to 4 cups/day of coffee (400 mg caffeine/day) has no harmful effects on health and it may even have protective effects on NCD (2). In this report, we focus on the outcomes for all types of cancer, cardiovascular diseases (CVD), type 2 diabetes (T2D), and obesity. The target population was healthy adults; no information on other populations such as children and pregnant women was collected.

2.2.2 Search strategy

To find relevant literature, we developed the search strategy for the database PubMed, including the term on the intervention (“coffee”) and the outcomes (“cancer”, “cardiovascular system”, “diabetes”, etc.) formulated as MeSH terms and as free text. We applied filters for human subjects, adult population, English language, publication years 2018-2021, and study design (review, systematic review, meta-analysis, and randomized controlled trial). The syntax is provided in the annex, chapter 2.2. We downloaded the retrieved references in the reference software Zotero, and after the deduplication, we screened the titles and abstracts. We retrieved 178 full-text articles for full-text screening, and finally included 57 studies in the review. Several articles provided information on more than one outcome.

2.2.3 Main findings

2.2.3.1 Cardiovascular diseases

The two systematic reviews and meta-analysis and the three narrative reviews reported mostly inversely associations between coffee and risk of CVD. Coffee does not appear to be harmful, and it generally has protective effects on CVD outcomes (3-7). The diverse CVD outcomes taken into consideration in these studies were stoke, coronary heart diseases, heart failure and arrhythmia.

2.2.3.2 Cancer

The twenty-four systematic reviews, meta-analyses, umbrella review, and the five narrative reviews showed a diverse pattern of results depending on the type of cancer. There is evidence for a protective effect of coffee on liver cancer (8-13), breast cancer in postmenopausal women (8, 14-16), endometrial cancer (9, 17), skin carcinoma (18, 19), and there may be a protective effect for brain cancer (20, 21), oral cancer (22) and thyroid cancer (23). There is no association, or controversial and confounding evidence on colorectal cancer (8, 24-27), prostate cancer (8, 28) and ovarian cancer (8, 29-31). Coffee showed to have some harmful effects, and to potentially function as risk factor for pancreatic cancer (8, 32-34) and for bladder cancer (8, 35, 36), even though for the latter, more evidence is needed controlling for smoking habits.

2.2.3.3 Diabetes

The two systematic reviews and meta-analysis, the narrative review and the randomized controlled trial showed that coffee had no significant effect on T2D, but mostly that it may have a protective effect on it (4, 37-39).

2.2.3.4 Obesity

The systematic review, the narrative review and the randomized controlled trial showed evidence of a modest association between coffee and reduce obesity (37, 40, 41).

2.2.4 Conclusion

The evidence for the beneficial effects of coffee on health outcomes vary by type of outcome, but it is generally positive. A picture emerges showing that coffee might have beneficial effects on several cancers (especially liver cancer), cardiovascular health, diabetes, and a modest effect on obesity, especially the green coffee beans. The controversial associations with certain type of cancer, and the potentially detrimental effect for other cancers like pancreatic and bladder cancer need to be further confirmed and studied. Coffee is also generally associated with lower risks of all-cause mortality. Even though many studies discerned between the doses of coffee consumed, the different type of coffee and the coffee processing should be better integrated in the future studies, taking into consideration other risk factors such as age, sex, smoking patterns, and other life habits. The focus of the evidence review was on studies of coffee consumption and not on the preparation of coffee, in particular milk and sugar. Evidence regarding dairy and SSBs, and their relationship with NCD, can be found in chapters 6.8 and 6.3, respectively.

In this report, depending on the type of outcome, the association was found to be positive, neutral, or negative. Overall, there was no evidence for a detrimental effect of coffee on health, with exception of a possible positive association between coffee and certain types of cancer. Several associations between coffee and specific outcomes were neutral or even protective, but the causality was often not possible to prove, especially because of the large amount of confounding variables that need to be taken into consideration, such as coffee preparation, stress levels, physical activity or smoking habits.

Table 5: Summary coffee intake and risk of NCD

Conclusion	**Class**	**Level**
Coffee generally has protective effects on CVD outcomes	I	B
Coffee may be a protective factor for several cancers like liver cancer, breast cancer in postmenopausal women, endometrial cancer, skin carcinoma, prostate cancer, brain cancer, oral cancer and thyroid cancer	I	A
Coffee showed confounding and controversial effects on colorectal and ovarian cancer	II	A
Coffee showed a potential harmful effect for pancreatic and bladder cancer	III	A
Coffee might have a protective effect on T2D	II	A
Coffee might affect weight in a moderate way	II	B

2.2.5 Recommendations

According to the latest evidence, a moderate consumption of coffee (up to 4 cups per day) can be considered potentially beneficial for many types of cancer (liver cancer, prostate cancer, endometrial cancer, melanoma cancer, breast cancer (in postmenopausal women), brain cancer and thyroid cancer), CVD and T2D. There is not enough evidence regarding obesity, even though it is hypothesized a modest positive association between coffee consumption and loss of weight. There is a contraindication of coffee consumption regarding bladder cancer and pancreatic cancer, for which an inverse association has been found. Regarding pancreatic cancer, evidence suggests a maximum consumption up to 3 cups per day.

Table 6: Estimation of optimal amount (cups/day) of coffee intake in relation to NCD.*

NCD	Optimal consumption
CVD	The intake of coffee, particularly in moderate doses (2-3 cups/day), does not appear to be harmful for cardiovascular conditions. On the contrary, habitual coffee consumption of 3-5 cups/day was associated with a 15% reduction in the risk of CVD (compared to non-consumers).
Cancer	
Liver cancer	Higher coffee consumption was associated with lower HCC risk (HR >3 cups/day vs. non-drinkers 0.73 (95% CI: 0.53-0.99) and *p* for trend<0.0001)
Prostate cancer	A reduction in the risk of prostate cancer of nearly 1% was observed for each increment of one cup of coffee per day
Bladder cancer	Increased risk between high (around > 4 cups/day) coffee consumption and bladder cancer
Endometrial cancer	One-cup increment per day was associated with 3% risk reduction (95% CI: 2-4%) in cohort studies
Pancreatic cancer	The risk of pancreatic cancer was increased by 5.87% (RR: 1.06; 95% CI 1.05-1.07) with the increment of one cup/day. A useful guide would be 3 cups/day.
Melanoma cancer	An increase in coffee consumption of one cup per day was associated with a 3% reduction in melanoma risk (RR 0.97; 95% CI 0.95-0.99). Higher the dose, up to 3 cups per day, lower the risk).
Breast cancer (postmenopausal women)	For every two cups of coffee consumed per day, the risk of breast cancer decreased by 2% (RR: 0.98; 95% CI: 0.97-1.00).
Brain cancer	Every one cup of coffee per day decreases the risk of glioma by 3% (RR: 0.97 (95% CI 0.94, 0.99), p= 0.016, $P_{non\text{-}linearity}$ = 0.054)
Thyroid cancer	The occurrence of TC was reduced by 5% with each one-cup increment of coffee consumption (up to 7 cups a day).
T2D	Mild-moderate coffee consumption (up to 4 cups/day), is associated with beneficial effects on hypertension and diabetes mellitus, with a risk decrease of T2D by 6% for each coffee cup-per-day.
Obesity	Higher coffee intake (from 4 to 6 cups/day) might be modestly associated with reduced obesity and modest loss of FM.

* Contrary to the other food groups, no estimations regarding minimal or maximal consumption could be derived.

Table 7: Results of the associations between coffee and health outcomes

Reference	Year	Type	Results	Grade
Cardiovascular disease				
(3)	2021	MA	Coffee consumption reduces the risk of overall stroke, especially ischemic stroke.	IA
(4)	2021	NR	Coffee reduces the risk of coronary heart disease, heart failure, arrhythmia, stroke, CVD and all-cause mortality. Studies included in this NR show that the major benefits are at 3-5 cups/day.	IB
(5)	2020	SR/MA	Limited and possible effects of coffee protective effects for CVD and its risk factors were found in the Korean population.	IIA
(6)	2018	NR	Habitual coffee consumption of 3-5 cups/day is associated with a 15% reduction in the risk of CVD (compared to non-consumers). There is no increased risk of CVD for those who already suffered a CVD event, even though more data are needed for people with hypertension.	IB
(7)	2019	NR	The intake of coffee, particularly in moderate doses (2-3 cups/day), does not appear to be harmful and may even be beneficial for cardiovascular conditions, including coronary artery disease, heart failure and arrhythmias.	IB
Cancer				
(8)	2021	NR	Coffee intake is inversely associated with risk of hepatocellular cancer and, to a slight extent, risk of breast cancer among postmenopausal women. The associations with oesophagus, pancreas, colon-rectum, kidneys, bladder, ovaries, and prostate, are less clear and conflicting.	I/IIB
(9)	2020	UR	There is highly suggestive evidence for an inverse association between coffee intake and risk of liver and endometrial cancer.	IA
Liver cancer				
(10)	2020	MA/SR	Drinking coffee provides benefits with a reduction in the risk of HCC or liver cancer. Higher doses of coffee (3 or more) have higher benefits in terms of risk reduction.	IA
(11)	2019	NR	Evidence, with consistency across study designs and populations, suggests that coffee intake probably reduces the risk of liver cancer. Future research should establish the causality of the association.	IB
(12)	2019	NR	Coffee lowers gastrointestinal and, especially, liver cancer risk in humans.	IB
(13)	2019	MA	Coffee consumption among Japanese people has a significant role in preventing liver cancer.	IA
Colorectal cancer				
(24)	2020	NR/SR	There are disparate results for any protective effect for coffee intake in colorectal cancer prevention. Certainty of evidence is very low.	IIA

Reference	Year	Type	Results	Grade
(25)	2018	MA	Moderate coffee consumption (less than 3 cups/day) may not be associated or weakly inversely associated with the risk of colorectal cancer in the Japanese population.	IIA
(26)	2019	MA	No evidence for the association between coffee consumption and colorectal cancer risk. When using pooled projects, the association between coffee consumption and colorectal cancer risk is controversial.	IIA
(27)	2019	SR/MA	No significant relationship was detected between colorectal cancer and coffee. Ethnicity could explain the heterogeneity of the studies.	IIA
Prostate cancer				
(28)	2021	MA/SR	Higher coffee consumption was significantly associated with a lower risk of prostate cancer.	IA
Bladder cancer				
(35)	2018	MA	Meta-analyses showed a 20% increase in risk of bladder cancer comparing the highest with the lowest consumption of coffee. Increasing intake of coffee were risk factors for bladder cancer.	IIIA
(36)	2020	SR	There was an increased risk between high (around > 4 cups/day) coffee consumption and bladder cancer among male smokers. No association among females and never smokers. Smoke could be a confounding factor.	IIIB
Oral cancer				
(22)	2020	SR	High vs low coffee intake was associated with a reduced risk of oral cavity cancer. High or intermediate coffee intake might have protective effects against oral cavity cancer.	IA
Endometrial cancer				
(17)	2018	MA	Protective effect of coffee consumption on the risk of endometrial cancer. Increased coffee intake might be particularly beneficial for women with obesity.	IA
Pancreatic cancer				
(32)	2020	NR	The evidence for the impact of coffee consumption on pancreatic cancer (PDAC) is rather mixed. In conclusion, PDAC patients could benefit, directly and indirectly, from drinking coffee. A useful guide would be 3 cups/day.	IIB
(33)	2019	MA	The risk of pancreatic cancer was increased by 5.87% with the increment of one cup/day. Coffee consumption was related with the increasing risk of pancreatic cancer in a dose-response manner.	IIIA
(34)	2019	MA	Little or no statistically significant association between coffee consumption and pancreatic cancer risk in never smokers.	IIA
Breast cancer				

Reference	Year	Type	Results	Grade
(14)	2018	MA	Meta-analysis may support the hypothesis that coffee consumption is associated with decreased risk of postmenopausal breast cancer.	IA
(15)	2021	MA	The meta-analysis found a negative correlation between coffee intake and breast cancer risk, especially in postmenopausal and European women.	IA
(16)	2021	NR	There is no association between coffee intake and breast cancer risk or a slight protective effect, even at high dosages. Coffee is inversely associated with breast cancer risk in postmenopausal women.	IB
Melanoma cancer				
(18)	2018	MA	An increase in coffee consumption of one cup per day was associated with a 3% reduction in melanoma risk. The study included up to 8 cups of coffee per day. Coffee intake may be inversely associated with incidence of melanoma.	IA
(19)	2018	MA	Caffeinated coffee might have chemopreventive effects against basal cell carcinoma (non-melanoma skin cancer) dose dependently (higher the dose, up to 3 cups/day, lower the risk).	IA
Brain cancer				
(20)	2021	SR/MA	Dose-response meta-analysis showed that for each cup of coffee per day (investigated range 0-8 cups/day) there is a decrease in the risk of glioma by 3%.	IA
(21)	2019	MA	Higher consumption of coffee may contribute to the lower development of brain cancer in Asian populations.	IA
Ovarian cancer				
(29)	2019	MA	There was no statistically significant association between caffeine intake or different types of coffee and the risk of ovarian cancer.	IIA
(30)	2019	SR/MA	No significant association was found between coffee intake and risk of ovarian cancer. There was an association between decaffeinated coffee consumption and risk of ovarian cancer.	IIA
(31)	2021	UR/ MA	A positive correlation between coffee drinking and OC risk was found. Only four studies were taken into consideration for meta-analysis, so more evidence should be collected.	IA
Thyroid cancer				
(23)	2020	MA	Coffee consumption was inversely associated with the TC occurrence in a linear dose-response manner (up to 7 cups/day). The occurrence of TC was reduced by 5% with each one cup increment of coffee consumption.	IA
Diabetes				

Reference	Year	Type	Results	Grade
(37)	2020	RCT	Consuming 4 cups/day of caffeinated coffee for 24 weeks had no significant effect on change insulin sensitivity compared with placebo.	IIB
(4)	2021	NR	Mild-moderate coffee consumption (2-3 cups/day), is associated with beneficial effects on hypertension and diabetes mellitus.	IB
(38)	2018	SR/MA	The risk of T2D decreased by 6% for each coffee cup-per-day (up to 5 cups/day were considered). Results were similar for caffeinated and decaffeinated coffee consumption.	IA
(39)	2021	SR/MA	Drinking coffee (up to 4 cups) may be inversely associated with the risk of mortality in patients with type 2 diabetes. More research is needed considering type of coffee, substances added to coffee, and history of CVD.	IIA
Obesity				
(37)	2020	RCT	Consuming 4 cups/day of caffeinated coffee for 24 weeks was associated with a modest loss of FM.	IIB
(40)	2019	MA	The meta-analysis suggests that higher coffee intake (higher intake levels investigated 6 cups/day) might be modestly associated with reduced obesity, particularly in men.	IIA
(41)	2021	NR	Coffee showed to exert anti-obesity effects in humans with several studies supporting the beneficial effects of coffee consumption toward obesity. However, several studies failed to show this effect.	IIB

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review.

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2.3 Sugar-sweetened beverages

Authors: Sarah Pannen, Sabine Rohrmann Reviewer: Undine Lehmann

2.3.1 Introduction

Sugar-sweetened beverages (SSBs) are defined as beverages containing added sugars or sweeteners such as high-fructose corn syrup, sucrose, glucose, maltose, lactose, honey, malt syrup, molasses, raw sugar or fruit juice concentrates and include a variety of soft drinks, sodas, fruit drinks, energy drinks, and vitamin-water drinks. Artificially sweetened beverages (ASBs), meanwhile, are defined as liquids that contain non-nutritive artificial sweeteners (e.g., aspartame, sucralose, and saccharine) (1-3). Despite this general definition for SSBs (and ASBs), there are differences in the scientific literature regarding serving sizes (from 250 to 330 ml) and types of beverages that are covered under the umbrella term SSB. In this review, articles on all types of SSBs (and ASBs) are included. Evidence on the health effects of fruit and vegetable juices is discussed elsewhere (see section “Fruit juices”).

2.3.2 Search strategy

A literature search for suitable articles was conducted in PubMed and EMBASE up to September 2021. Search strings included 'sugar sweetened beverage', 'artificially sweetened beverage', 'soft drink', ' carbonated beverage', 'cardiovascular', 'diabetes mellitus', 'cancer', 'neoplasms' and 'obesity', and included a mixture of MeSH (Medical Subject Headings) terms and text words to maximize identification of relevant articles. In addition, search filters by article type (Meta-analysis, systematic reviews, reviews and randomized controlled trials), species (humans, healthy adults), language (English) and publication date (within the last 3 years) were applied. The syntax is provided in the annex, chapter 2.3.

2.3.3 Main findings

Twenty-three (23) articles published in the last three years were included in the evaluation of the effects of SSBs regarding CVD, cancer, T2D and overweight/obesity. The majority of meta-analyses reported a harmful association between SSB consumption and the incidence of major non-communicable diseases and related health outcomes.

2.3.3.1 Cardiovascular disease

Assessment of the health effects of SSB consumption indicated an overall positive association between high SSB intake and increased risk of CVD (overall CVD (4-6); CVD mortality (6-9); stroke (10, 11); coronary heart disease (10); hypertension/increased blood pressure (12-14) and heart failure (10).

2.3.3.2 Cancer

While one meta-analysis found a positive association between SSB consumption and overall cancer risk (15), four meta-analyses reported positive (8, 15) or null associations (7, 9) for SSB-related cancer mortality.

Heterogeneous findings were reported on the association of SSB consumption with the risk of different cancer types. While a consistent statistically significant positive association between SSB consumption and breast cancer was observed in two meta-analyses (15, 16), statistically significant positive associations and non-statistically significant positive tendencies were observed for HCC (15, 17) and colorectal cancer risk (15, 16, 18). Meta-analyses further found that a high consumption of SSBs may be associated with an increased risk for prostate cancer (16) and prostatic cancer mortality (15). With respect to pancreatic cancer risk, neither the association with SSB consumption based on cohort studies nor the association based on case-control studies reached statistical significance (19). This finding was in line with other meta-analyses suggesting no evidence for an association of SSB with pancreatic cancer risk (15, 16). While one meta-analysis reported a statistically significant inverse association for SSB consumption and risk of glioma and non-cardia gastric cancer, no evidence for associations of SSB with oesophageal, gastric, renal, bladder, ovary, endometrial, pancreatic, hematopoietic, nasopharyngeal and biliary tract cancer was found (15).

2.3.3.3 Diabetes

There was an overall positive association between high SSB intake and increased risk of T2D (4, 5, 14, 20-23).

2.3.3.4 Obesity

There was a positive association between SSB intake and overweight/obesity (5, 14, 24, 25). One 12-month RCT in a population of habitual SSB consumers was found that showed no difference in body weight and fat mass with continued SSB consumption compared with replacing SSBs with either ASBs or unsweetened beverages. However, in the subgroup of individuals with central obesity, this replacement was associated with a decrease in body weight and fat mass (26).

2.3.4 Artificially-sweetened beverages

Although not being the primary focus of this review, the health effects of ASBs, often considered a “healthier alternative” to SSBs, should be briefly mentioned here. Overall, although the number of meta-analyses was smaller, in line with the findings on SSBs, ASB consumption was associated with increased risk of CVD (overall CVD (4); CVD mortality (7-9) and hypertension (14).

Positive and null associations were observed for the association of ASBs with cancer mortality (7-9).

ASB consumption was associated with increased risk of T2D (4, 14, 21-23), and obesity (14).

These findings are consistent with those summarized in the previous 2019 FCN report (27), stating that there is evidence for adverse health effects associated with the consumption of ASBs possibly involving mechanisms, such as alterations of food intake control by the brain and changes in the gut microbiota. Furthermore, it was concluded in the 2019 FCN report that ASBs should not be recommended as a substitute for SSBs as there is no evidence of a beneficial effect of replacing SSBs with ASBs. Instead, water should be the main source of fluid intake.

2.3.5 Conclusion

Despite the indication of an overall positive association of SSBs with morbidity and mortality of the selected NCD, it must be considered that even though findings from different meta-analyses were largely consistent (with respect to CVDs, T2D and obesity) the certainty of evidence was rated as low or very low by the authors for the majority of meta-analyses and systematic reviews included in this literature review. While most studies showed that high SSB consumption was detrimental to health compared with low SSB consumption, a few studies that examined dose-response associations suggested that even one SSB serving per day (250 to 330 ml) can lead to adverse health effects, indicating a possible dose-dependent association between SSBs and NCD. However, it should be noted that meta-analyses were mainly based on prospective cohort studies, and heterogeneity within the included studies was often moderate to high. Therefore, conclusions drawn based on current evidence from epidemiological studies need to be done carefully and observed associations should not necessarily be considered causal. The present observations on the links between SSB intake and non-communicable disease risks are consistent with those summarized in the previous FCN report published in 2019, which covered the scientific evidence from literature published between 2012 and 2017. Further in-depth research (especially with respect to the association of SSBs and the risk of different cancer types) is needed to better understand the role of SSBs in the development and progress of NCD.

Table 8: Summary SSB intake and risk of NCD

Conclusion	**Class**	**Level**
Increasing SSB intake increases the risk of cardiovascular diseases	III	A
Increasing SSB intake increases the risk of type 2 diabetes	III	A
Increasing SSB intake might increase the risk of cancer	II	A/B
Increasing SSB intake might increase the risk of obesity	II	A

2.3.6 Recommendations

Table 9: Estimation of minimum, optimal, and maximum amount of SSB intake in relation to NCD.

Food group	NCD	Minimum	Maximum	Optimal
SSB	CVD	0	0	0
SSB	Cancer	0	0	0
SSB	T2D	0	0	0
SSB	Obesity	0	0	0

Table 10: Results of associations between SSB (and ASB) intake and health outcomes

Ref.	Year	Study	Food type	Results	Grade
Cardiovascular disease					
(11)	2018	SR and M	SSB	Dose-response analysis suggested no statistically significant association between SSB consumption and stroke incidence, but there tended to be a marginally positive association with the highest (compared to the lowest) SSB consumption and an increased risk of stroke (RR: 1.10; 95% CI: 1.00-1.20).	IIA
(13)	2019	SR and MA of PCS	SSB	A meta-analysis of 13 cohorts showed an increase in hypertension risk when comparing highest to lowest SSB consumption (RR: 1.17; 95% CI: 1.11-1.23; I^2=66%) and linear dose-response analysis found an increase in hypertension incidence with each 355 ml/day serving of SSB ($RR_{per-355-ml}$: 1.10; 95% CI: 1.08-1.12; I^2=73%). Certainty of the evidence was reported to be low.	IIIA
(10)	2019	SR and MA of PCS	SSB	While a 10% increase in coronary heart disease risk (RR: 1.10; 95% CI: 1.01-1.20; I^2=50%), and a 9% increase in stroke risk (RR: 1.09; 95% CI: 1.01-1.18; I^2=0%) was found with high compared to low SSB intake, no association was observed with heart failure risk. Dose-response analysis showed a positive association of each additional 250 ml of SSB per day with the risk for coronary heart disease (RR: 1.17; 95% CI: 1.11-1.23; I_2=0%; $P_{heterogeneity}$=0.66; n=4), stroke (RR: 1.07; 95% CI: 1.02-1.12; I_2=0%; $P_{heterogeneity}$=0.59; n=6) and heart failure (RR: 1.08; 95% CI: 1.05-1.12, n=1).	IIA/IIIA
(14)	2020	SR and MA of PCS	SSB (and ASB)	High vs. low SSB (and ASB) intake were significantly associated with increased hypertension risk. Dose-response meta-analysis reported that each 250 ml/day increment in SSB (and ASB) consumption was associated with a 10% (and 8%) increase in risk for hypertension (SSB: RR: 1.10; 95% CI: 1.06-1.14; I^2=58.4%; ASB: RR: 1.08; 95% CI: 1.06-1.10; I^2=24.3%).	IIIA
(12)	2020	SR and MA	SSB	A meta-analysis of two studies showed a 19% increase in elevated blood pressure/hypertension risk with high SSB consumption in a Korean population (95% CI: 1.04-1.36).	IIIA
(5)	2021	R of PCS	SSB	A qualitative literature review based on data from an Asian population found that a high level of SSB consumption was associated with a higher CVD risk, with heterogeneous findings for different types of CVD outcomes.	IIIB

Ref.	Year	Study	Food type	Results	Grade
(4)	2021	SR and MA of PCS	SSB (and ASB)	SSB (and ASB) intake contributed to a higher risk for CVDs (highest vs. lowest consumption category), and dose-response analysis showed that each additional SSB (and ASB) serving/day increased the risk by 9% (and 8%) with moderate heterogeneity (SSB: RR: 1.09, 95% CI: 1.07-1.12; I^2=42.7%; ASB: RR: 1.08; 95% CI: 1.04-1.11; I^2 =45.5%).	IIIA
(6)	2021	SR and MA of PCS	SSB	The highest compared to the lowest level of SSB consumption was associated with a 9% (95% CI: 1.01-1.18; I^2=28.8%) and a 20% (95% CI: 1.10-1.31; I^2=11.7%) increased CVD incidence and CVD mortality risk, respectively. Dose-response analysis showed an 8% (incidence: 95% CI: 1.02-1.14; I^2=43.0%; mortality: 95% CI: 1.04-1.13; I^2=40.6%) linear increase in both, CVD incidence and CVD mortality per serving/day increment in SSB consumption.	IIIA
(8)	2021	SR and MA of PCS	SSB (and ASB)	An increase in SSB (and ASB) consumption by 250 ml/day was associated with an increased risk of CVD mortality (HR 1.08, 95% CI: 1.02-1.14; I^2=70%), while the level of certainty of evidence was reported to be low. Dose-response association was observed to be non-linear.	IIIA
(9)	2021	SR and MA of PCS	SSB (and ASB)	Higher SSB (and ASB) consumption were positively associated with a higher risk for CVD mortality. Dose-response analysis reported an 8% (and 1%, non-statistically significant) increased risk for CVD mortality with each SSB (and ASB) serving of 355 ml/day (SSB: HR 1.08; 95% CI: 1.04-1.12; ASB: HR 1.01 95% CI 0.96-1.07,	IIIA
(7)	2021	SR and MA of PCS	SSB (and ASB)	The meta-analysis suggested a greater risk of CVD mortality with high SSB (and ASB) consumption (SSB: HR: 1.20; 95% CI: 1.05-1.38; I^2=76.1%; ASB: HR: 1.23; 95% CI: 1.001-1.50; I^2=82.5%). Dose-response analysis reported a higher risk for CVD mortality for each 250 ml/day serving of SSB (HR: 1.13; 95% CI: 1.06-1.20) and ASB (HR 1.067; 95% CI: 1.001-1.136). Both SSB, and ASB indicated a linear relationship with CVD mortality.	IIIA
Cancer					
(18)	2018	SR and MA	SSB	No association was observed for SSB consumption and colorectal cancer risk.	IIA
(19)	2019	MA	SB (SSB and ASB)	A meta-analysis of 5 cohort and 4 case-control studies found no statistically significant association between SB consumption and pancreatic cancer risk.	IIA

Ref.	Year	Study	Food type	Results	Grade
(15)	2021	SR and MA (of PCS and CCS)	SSB	Dose-response analysis showed a linear increase in overall cancer risk per serving/day increment in SSB consumption (RR: 1.04; 95% CI: 1.01-1.09). The highest compared to the lowest level of SSB consumption was associated with an increased overall cancer risk (RR 1.12; 95% CI 1.06-1.19) and cancer mortality (RR: 1.07; 95% CI: 1.01-1.14), respectively. While the greatest increase in SSB-associated risk was observed for breast cancer, HCC, colorectal cancer, and prostatic cancer mortality, a significant inverse association was reported for SSB consumption and risk of glioma and non-cardia gastric cancer. Meta-analyses suggested no evidence for associations of SSB with esophageal, gastric, renal, bladder, ovary, endometrial, pancreatic, hematopoietic, nasopharyngeal and biliary tract cancer.	IIIA IA/IIIA IIA
(8)	2021	SR and MA of PCS	SSB (and ASB)	While a linear dose-response association was observed between SSB (and ASB) consumption and cancer mortality (SSB: $P_{non\text{-}linearity}$=0.7914; ASB: $P_{non\text{-}linearity}$=0.36), an increase in SSB intake by 25 0ml/day had no statistically significant effect on cancer mortality (HR= 1.02; 95% CI: 0.99-1.05; I_2=63%), and the certainty of evidence for the effects of increasing SSB (and ASB) consumption and cancer mortality was rated as very low and therefore uncertain.	IIA
(9)	2021	SR and MA of PCS	SSB (and ASB)	No association was observed between SSB (and ASB) consumption and cancer mortality.	IIA
(16)	2021	SR and MA	SSB	An increase in breast (RR: 1.14; 95% CI: 1.0-1.3) and prostate cancer risk (RR: 1.18; 95% CI: 1.10-1.27) was observed in the highest consumption category of SSBs, compared to the lowest category. Non-statistically significant positive tendencies were reported between SSB consumption and colorectal and pancreatic cancer risk, and for ASB and pancreatic cancer risk.	IIIA IIA
(17)	2021	SR	SSB	Based on two studies included in the systematic review, the authors concluded that there may be a positive association between HCC risk and SSB intake.	IIB
(7)	2021	SR and MA of PCS	SSB (and ASB)	No statistically significant association was observed between risk of cancer mortality and consumption of SSB (and ASB).	IIA

Ref.	Year	Study	Food type	Results	Grade
Diabetes					
(20)	2018	UR of MA	SSB	Based on the meta-analyses included in the umbrella review, the authors concluded that there is a convincing or highly suggestive association between increased SSB intake and T2D.	IIIA
(22)	2019	UR of MA	SSB (and ASB)	Both, SSB (and ASB) consumption were associated with an increased incidence of T2D (SSB: HR: 1.26; 95% CI: 1.11-1.43; ASB: HR: 1.24; 95% CI: 1.10-1.39). The quality of evidence from the dose-response meta-analyses was rated by the authors with high for SSB and moderate for ASB.	IIIA
(21)	2019	MA of PCS	SSB (and ASB)	An 16% (and 18%) increase in T2D risk in the subsequent 4 years was observed following an increase in SSB (and ASB) intake by >0.50 serving/day (SSB: HR: 1.09; 95% CI: 1.03-1.17; ASB: HR: 1.18; 95% CI: 1.02-1.36), while replacement of one daily SSB serving with a non-sugar containing (and non-ASB) beverage resulted in a 2-10% decrease in type 2 diabetes risk.	IIIA
(14)	2020	SR and MA of PCS	SSB (and ASB)	High (vs. low) SSB (and ASB) intake were significantly associated with increased risk for T2D. Dose-response meta-analysis reported that each 250 ml/day increment in SSB (and ASB) consumption was associated with a 19% (and 15%) increase in risk for T2D (SSB: RR: 1.19: 95% CI: 1.13-1.25; I^2=82.4%; ASB: RR: 1.15; 95% CI: 1.05-1.26; I^2=92.6 %).	IIIA
(23)	2020	UR of SR and MA	SSB (and ASB)	Significant positive associations between high (vs. low) SSB (and ASB) consumption and the risk for T2D were reported. Dose-response analysis showed a 21% (and 25%) increased risk for T2D with a 250 ml/day increment in SSB (and ASB) consumption (SSB: RR: 1.21; 95% CI: 1.12-1.31; ASB: RR: 1.25; 95% CI: 1.18-1.33).	IIIA
(5)	2021	R and MA of PCS	SSB	High SSB consumption was associated with a 51% higher risk for T2D in an Asian population while high heterogeneity was reported by the authors (RR 1.51; 95% CI: 1.15-1.98; I^2=76%).	IIIA
(4)	2021	SR and MA of PCS	SSB (and ASB)	SSB (and ASB) intake contributed to a higher risk for T2D (highest vs. lowest consumption category) and dose-response analysis showed that each additional SSB (and ASB) serving/day increased the risk by 27% (and 13%) with high heterogeneity (SSB: RR 1.27; 95% CI: 1.15-1.41; I^2=80.8%; ASB: RR 1.13; 95% CI: 1.03-1.25; I^2=78.7%).	IIIA

Ref.	Year	Study	Food type	Results	Grade
Obesity					
(25)	2019	SR and MA	SSB	A meta-analysis found that the risk of overweight/obesity was increased (RR: 1.20; 95% CI: 1.01-1.43; I^2=23%) in high vs. low SSB intake analysis and dose-response analysis showed that each additional 250 ml SSB serving/day increased the risk by 5% (RR: 1.05; 95% CI: 1.00-1.11; I^2=33%). The association between SSB and risk of overweight/obesity was linear. Similarly, meta-analysis suggested an increased risk of abdominal obesity (RR: 1.34; 95% CI: 1.13-1.59; I^2=90%) in high compared with low SSB consumption, with a dose-response (non-linear) increased risk of 12% (RR: 1.12; 95% CI: 1.04-1.20; I^2=38%) per 250 ml SSB serving/day. For risk of weight gain, a 23% increased risk was observed in high compared to low SSB consumption (RR: 1.23; 95% CI: 1.11-1.37; I^2=0%). Based on data from only one study, a positive non-statistically significant increase in risk for weight gain of 12% per 250 ml SSB/day was reported (RR: 1.12; 95% CI: 0.82-1.53).	IIIA IIIA IIIA/IIA
(24)	2020	RCT	SSB (and ASB)	A 12-month RCT on habitual SSB consumers observed no difference in body weight and fat mass among individuals continuing to consume SSBs compared to individuals replacing SSBs with either ASBs or unsweetened beverages. However, in a subgroup analysis among individuals with central obesity, replacing SSBs with either ASBs or unsweetened beverages was associated with decreased body weight and fat mass.	IIB IIIB
(14)	2020	SR+MA of PCS	SSB (and ASB)	High SSB (and ASB) intake were significantly associated with increased risk for obesity. Dose-response meta-analysis reported that each 250ml/day increment in SSB (and ASB) consumption was associated with a 12% (and 21%) increase in risk for obesity (SSB: RR: 1.12; 95% CI: 1.05-1.19; I^2=67.7%; ASB: RR: 1.21; 95% CI: 1.09-1.35; I^2=47.2%).	IIIA
(24)	2021	SR+MA of PCS	SSB	High compared to low SSB consumption tended to be associated with a non-statistically significant 14% increase in waist circumference (95% CI: 0.86-1.51; I^2=90.8%).	IIA
(5)	2021	R of PCS	SSB	A qualitative literature review based on data from an Asian population observed that a high level of SSB consumption was associated with greater weight gain.	IIIB

ASB: Artificially sweetened beverages; CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SB: Sweetened beverages; SR: Systematic review; SSB: Sugar-sweetened beverages; UR, umbrella review.

2.3.7 References

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2.4 Fruit Juice

Authors: Undine Lehmann. Reviewers: Pedro Marques-Vidal, Esther Infanger

2.4.1 Introduction

Since the WHO changed in 2015 their recommendation to limit the intake of sugars from added to free sugars, which include sugars (monosaccharides and disaccharides) naturally present in fruit juice and fruit juice concentrates, fruit juice became under scrutiny (1). Fruit juice is defined as: "an unfermented, fermentable juice made from the edible parts of fresh or cold-preserved healthy and ripe fruits of one or more species. Fruit juice has the characteristic colour, aroma, and flavour of the fruit from which it is derived". It is not allowed to add sugar to fruit juice. In contrast, "Fruit nectar is an unfermented fermentable beverage produced by adding water, with or without added sugars or honey, to fruit juice, fruit juice from concentrate, fruit juice extracted from water, fruit juice concentrate, fruit pulp or concentrated fruit pulp, or a mixture thereof." (2).

Food-based dietary guidelines are not consistent in the consumption recommendation of fruit juices (3). Many countries classify fruit juice within the fruit and vegetable group, but recommend moderation in consumption to not more than one serving of fruit juice accounted as fruit per day. However, in several countries, the classification of fruit juice and intake recommendation is unclear or undefined (3). In the Swiss Food Pyramid, juice is visually depicted in the vegetable and fruit level and in written recommendations, it is stated that of the five recommended portions of fruit and vegetables, one portion can be replaced by 2 dL vegetable or fruit juice without added sugars (4).

In the expert report of the Federal Committee for Nutrition (FCN), it was summarized that literature does not support the assumption that one serving of fruit juice has health benefits comparable with whole fruits (5). It was therefore recommended to withdraw a possible replacement of one serving of fruit with one serving of fruit juice, and instead to group fruit juice together with sugar-sweetened beverages (SSB) and other sweets, salty snacks, and alcoholic beverages at the top of the pyramid. For this level, a moderate consumption is recommended.

2.4.2 Search strategy

We searched the databases PubMed and EMBASE to identify publications about the following NCD: CVD, cancer, T2D and obesity, and the food group "fruit juice" in combination. To identify relevant results, we set the following filters: humans, English, from 2018 onwards, reviews, systematic reviews and meta-analyses. We were able to identify 20 results for the title and abstract screening, which we imported to the systematic review tool "Rayyaan". In the following full-text screening, we excluded 16 studies for meeting the exclusion criteria such as "wrong outcome", "wrong food" or "wrong population". At the end of this process, we found four eligible studies, which were used for this paper (further details are available in the document "Syntax Fruit Juice"). Another study from 2017 (6) was not identified through this search because the term fruit juice was not mentioned in the title or abstract. However, as an included review and meta-analysis (1) analysed this review, it was not added separately. The syntax is provided in the annex, chapter 2.4.

2.4.3 Main findings

Four reviews and meta-analyses of medium to high quality were included in this summary.

2.4.3.1 <u>Cardiovascular disease</u>

A systematic review of meta-analyses from 2019 investigated the association between fruit consumption including fruit juice and chronic diseases and included seven articles with fruit juice (1). Fruit juice (unsweetened) was not associated with CVD. However, consumption of fruit juice was associated with a 33% reduced risk of total stroke. No association was found for the following risk factors of CVD: total cholesterol, LDL-C, HDL-C, and systolic blood pressure, while there was a significant reduction in diastolic blood pressure of 2.07 mm Hg (1).

2.4.3.2 Cancer

In the systematic review of meta-analyses from (1), fruit juice (unsweetened) was not associated with total cancers, or risk of colon cancer or breast cancer.

2.4.3.3 Diabetes

One systematic review and meta-analysis investigated the association between SSB and fruit juice with T2D (7). It included 13 studies with fruit juice. A higher consumption of fruit juice was associated with an increased incidence of T2D by 5% before obesity adjustment and by 7% after obesity adjustment per one serving per day. However, the positive association varied by study design and study inclusion criteria. Furthermore, potential publication bias and residual confounding were likely to exist and therefore, evidence for fruit juice was rated as low. Hence, it was evaluated that for fruit juice the effect was non-significant after excluding any single study supporting the positive association. The authors concluded that fruit juices are unlikely a healthy alternative compared to the consumption of SSB for the prevention of T2D (7).

A recent systematic review of meta-analyses from (1) found that fruit juice (unsweetened) was not associated with T2D. However, fruit juice consumption was associated with an increased HOMA-IR index of 0.595 (an indicator of insulin resistance). No association was found for fasting glycaemia or insulinaemia. In contrast, compared with 100% fruit juice consumption, the consumption of fruit nectar (sweetened fruit juices) was associated with a significantly increased (28%) risk of T2D (1).

2.4.3.4 Obesity

One systematic review investigated the association of fruit consumption including fruit juice and obesity status in adults (8). The included five RCTs added fruit and fruit juice (up to 500 ml/d) to the diet under isocaloric conditions and found no significant effect on weight gain. However, small sample sizes and inconsistency in results limited the strength of evidence. Further, five RCTs compared different fruits and among them, different fruit juices but again, the results were methodologically weak because, for example, energy intake was not reported. The prospective cohort studies either did not include fruit juice or did not differentiate in the results between whole fruits and fruit juice. The only study that specifically investigated fruit juice was based on three large cohort studies and found an increased weight gain with fruit juice consumption already at one serving per day (9); this study was also included in the review from Fardet et al. (1). Hebden et al. concluded a reduced long-term risk of obesity with increasing fruit consumption or a nonsignificant association and in contrast, a weight gain promoting long term effect of fruit juice (8).

The systematic review of meta-analyses from (1) indicated that consumption of fruit juice was associated with a significant weight gain of 0.22 kg per standard serving (i.e., generally 125 mL) over 4 years, based on the same review from Pan et al. (2013) as in the review by Hebden et al. (2017) above. In contrast, the consumption of whole fresh fruits was associated with a significantly decreased (17%) risk of obesity. No pooled analysis or meta-analysis was found that assessed obesity, weight gain, or waist circumference in relation with nectar consumption.

2.4.3.5 Mortality

A recently published analysis of two cohort studies and a meta-analysis of 26 cohort studies investigated the association between fruit and vegetable intake and mortality (10). Subgroups such as fruit juices could be analysed separately. Higher intakes of fruit juices were not associated with mortality, contrary to a reduction of total mortality and cause-specific mortality attributable to cancer, CVD, and respiratory disease by the consumption of five servings a day of fruits and vegetables. Evidence was judged as high (10).

2.4.4 Conclusion

Fardet et al. summarized that overall, whole fruits seem more protective against chronic diseases than fruit juice (1). The major limitation of this review was that the included studies did not always specify whether the fruit juices contained added sugars. It was stated that there is still a lack of high-quality studies investigating the association between fruit processing and health outcomes. Also Wang et al. (2021) pointed out that due to different health effects, fruit juices should not be grouped within the fruits and vegetable group and thus, their study does not support the current Dietary Guidelines for Americans that include fruit juice in the fruit and vegetable group (10).

The lowest dose that was indicated as detrimental for health was 125 ml/day, with an effect on weight gain, equal to one small serving (vs. 200 ml indicated as one serving in the Swiss Food Pyramid).

Mechanistic explanations for the differences between whole fruits and fruit juices include a higher glycaemic load and a different nutrient composition including different (poly)phenol profiles and bioavailability (10, 11).

It has to be noted that at current stage it cannot be answered whether there are differences within the fruit juice group, for example some juices such as dark-coloured, polyphenol-rich juices providing health benefits similar to their whole fruit counterparts (11).

Table 11: Summary fruit juice intake and risk of NCD

Conclusion	Class	Level
Increasing fruit juice intake might reduce the risk of CVD	II	A
Increasing fruit juice intake does not modify the risk of cancer	II	A
Increasing fruit juice intake does not modify the risk of diabetes	II	A
Increasing fruit juice intake increases the risk of obesity	III	A

2.4.5 Recommendations

Associations between fruit juice consumption and CVD are inconsistent. While there is currently no indication that fruit juices provide the same health benefits as fruits and vegetables in exhibiting protective effects against CVD with high evidence, fruit juice reduced the risk for stroke with high evidence. Fruit juice does not provide protective effects against cancer with high evidence. Effects on T2D were neutral or slightly negative (increased risk factors) with moderate evidence. Increased fruit juice consumption of already one small serving per day resulted in increased weight gain in adults with moderate evidence.

Concluding, fruit juice does not provide positive health effects on the investigated NCD comparable with whole fruits except for a reduction in stroke. Therefore, they should not be included in the fruit and vegetable level of the Swiss Food Pyramid, in line with the recommendation of the previous report of the FCN (5). The position of fruit juice in the Food Pyramid has to be revised.

Vegetable juice is consumed in much lower amounts compared to fruit juice and there are insufficient data to conclude on health effects. However, a similar situation to fruit juice is assumed.

Table 12: Estimation of minimum, optimal, and maximum amount of fruit juice intake in relation to NCD

Food group	NCD	Minimum	Maximum	Optimal
Fruit juice	CVD	-	125 ml	0
Fruit juice	Cancer	-	125 ml	0
Fruit juice	T2D	-	0	0
Fruit juice	Obesity	-	0 §	0

§, per 1 serving/day: +0.22 kg weight gain over 4 years, while one serving was not clearly defined (most likely 1 US cup=237 ml).

Table 13: Results of the associations between fruit juice and health outcomes

Ref.	Year	Study	Food Type	Results	Grade
Cardiovascular disease					
(1)	2019	SR of MA	Fruit and fruit Juice	Fruit intake was negatively associated with disease risk, while associations between unsweetened fruit juice and CVD were n.s.	+/-
(1)	2019	SR of MA	Fruit and fruit Juice	Fruit juice intake was associated with reduced risk of stroke	-
(10)	2021	MA (+2 Cohort Studies)	Fruit Juice	Fruit juice intake was not associated with cause-specific mortality	+/-
Cancer					
(1)	2019	SR of MA	Fruit and Fruit Juice	Fruit juice intake was not associated with total cancer risk	+/-
(10)	2021	MA (+2 Cohort Studies)	Fruit Juice	Fruit juice intake was not associated with cause-specific mortality	+/-
Diabetes					
(7)	2015	SR and MA	Fruit Juice	After adjustment, higher intakes of fruit juice were not associated with a greater incidence of type 2 diabetes	+/-
(1)	2019	SR of MA	Fruit and Fruit Juice	Fruit juice intake was not associated with type 2 diabetes. Sweetened fruit juice intake was associated with a significantly increased (28%) risk of type 2 diabetes.	+/- +
Obesity					
(8)	2017	SR	Fruit Juice	Fruit juice intake appears to have the opposite effect compared to fruit, with higher intakes associated with greater weight gain over the long term (16-20 years), particularly among obese individuals.	+
(1)	2019	SR of MA	Fruit and Fruit Juice	Fruit juice intake was associated with a significant weight gain per standard serving.	+

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review. Summary result: + positive association between consumption and health outcome; +/- no association; - neg. association (inverse/ protective)

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2.5 Fruits and vegetables

Author: Nena Karavasiloglou, Sabine Rohrmann Reviewer: Undine Lehmann

2.5.1 Introduction

The term vegetables usually refers to the edible parts of plants, including roots, stems, and stalks, as well as flowers and grains that are used as vegetables. With the term fruits, we usually refer to the edible parts of plants, trees, bushes, or vines that contain seeds and pulpy tissue and usually have a sweet or tart taste. While fruit and vegetable composition depend on various factors, they are good sources of dietary fibre, a wide variety of vitamins, minerals, and other bio-active compounds (1). The current Swiss food pyramid recommends the daily consumption of 3 portions of vegetables and 2 portions of fruits (portion size ~120 g) (2). This report complements the previous FCN report on the association between fruits and vegetables and NCD (3).

2.5.2 Search strategy

A literature search was conducted in PubMed and EMBASE (10/08/2021). We imposed no limitations on the type of fruit and vegetables included in this review. Articles that reported results on fruit and vegetables (as an overall category), individual types (e.g., citrus fruits), or individual fruits or vegetables (e.g., tomato) were retained. Articles only focusing on fruit or vegetable extracts, compounds within fruits or vegetables, whole dietary patterns (e.g., the Mediterranean diet), or juices were excluded.

The studies mainly focused on adult populations and the outcomes reported below. The search was limited to humans, articles published in 2018 or later, and written in English. The syntax for the literature search in both databases is provided as supplementary material. Additional studies were identified through external sources and were added to the evidence pool. The syntax is provided in the annex, chapter 2.5.

2.5.3 Main findings

Thirteen studies met our inclusion criteria. Most studies reported an inverse association between fruit and/or vegetable intake and the selected non-communicable disease morbidity and mortality. In these studies, the pattern of associations was consistent and in the same direction.

2.5.3.1 <u>Cardiovascular disease</u>

The studies identified by our literature search that met our inclusion criteria reported evidence of an inverse association between higher fruit and/or vegetable consumption and the risk for coronary heart disease, cardiovascular disease, stroke, and mortality (4, 5).

2.5.3.2 <u>Cancer</u>

Higher fruit and/or vegetable intake was inversely associated with the risk for different cancers, including colorectal (6), liver (vegetable intake (7)), and lung (8) cancers. In contrast, higher chili pepper intake was associated with increased risk for gastric cancer (9).

Some of the included studies contradicted the previous results, reporting instead non-significant/null associations (10, 11). The study by Fardet et al., specifically, that mostly reported null associations, focused on the level of processing of fruits (e.g., whole fruits, dried fruits, canned fruits) (12). Based on their aim, they excluded various studies in which the level of processing was not reported, so their results might not be representative of the entire literature on fruit and vegetable consumption and their relationships with health outcomes.

Differential results were reported in some studies across different vegetable subtypes or personal/study characteristics. The results on colorectal cancer, when assessed by study type, remained significant for case-control, but not for cohort studies (8). An inverse association between fruit intake and lung cancer risk was seen in current (-14% risk) and former (-9% risk) smokers, while it appeared not statistically significant for never smokers where heterogeneity was seen between studies (I^2=27.2%) (8). A 40% and a 20% decrease in cervical cancer risk was observed in women with the highest intake of vegetables and fruits respectively, compared to the lowest category. However, when human papillomavirus (HPV) infection was considered, the association was evident only in studies without HPV adjustment, suggesting that HPV infection may have confounded the observed associations (13). Regarding the results for liver cancer, subgroup analysis suggested an inverse association between vegetable intake and liver cancer in males, but not females, while no differences were observed by region and mean age of participants (7). While a non-significant inverse association between vegetable intake and HCC was reported in one of the identified studies, specific vegetable subgroups were reported to have significant inverse associations, indicating a protective effect against HCC (14).

2.5.3.3 Diabetes

Higher fruit and vegetable consumption was also associated with lower T2D (green leafy and cruciferous vegetables (15) risk.

2.5.3.4 Obesity

Higher fruit and vegetable consumption was also associated with lower obesity and weight gain (10, 12, 16).

2.5.4 Conclusion

Most studies reported beneficial associations between fruit and vegetable intake and the selected non-communicable disease morbidity and mortality. Most associations remained the same in subgroup analyses, with some showing differential results depending on specific characteristics (e.g., sex, smoking status). The studies exploring the nature of the association reported a nonlinear increase in benefits with increasing intake. The beneficial effects of consumption of ≥2 servings of fruits and ≥3 servings of vegetables per day, and the existing food-based dietary recommendation, are supported by the current literature. Due to the heterogeneity between studies (and the comparison high vs. low, presented in many), it was difficult to determine a minimal, optimal, or maximal consumption with respect to cancer and T2D. All studies, except for one, were performed without specific details on the degree of processing. More studies on the topic are needed before considering differentiating the recommendation on fruits and vegetables by the degree of processing.

Table 14: Summary fruit & vegetable intake and risk of NCD

Conclusion	**Class**	**Level**
Fruit		
Increasing fruit consumption decreases the risk of CVD	I/II*	A
Increasing fruit consumption decreases the risk of cancer	I/II**	A
Increasing fruit consumption might decrease the risk of T2D	II	A
Increasing fruit consumption decreases the risk of obesity/weight gain	I/II	A
Vegetables		
Increasing vegetables consumption decreases the risk of CVD	I/II*	A
Increasing vegetables consumption decreases the risk of cancer	I/II	A
Increasing vegetables consumption decreases the risk of T2D	I/II	A
Increasing vegetables consumption decreases the risk of obesity/weight gain	I/II	A

* depends on CVD outcome; ** depends on cancer type and/or fruit and vegetable type and/or lifestyle characteristics (e.g., smoking).

2.5.5 Recommendations

Table 15: Estimation of minimum, optimal, and maximum daily amount of fruits & vegetables intake in relation to NCD

Food group / NCD	Minimum	Maximum	Optimal
Fruits			
CVD	200 g/day	--	400 g/day
Cancer	--	--	--
T2D	--	--	--
Obesity/weight gain	--	--	3 servings (~360 g*)
Vegetables			
CVD	200 g/day		400 g/day
Cancer	--	--	--
T2D	--	--	--
Obesity/weight gain	--	--	3 servings (~360 g*)

*The conversion to grams is based on the portion size for fruit and vegetables in the Swiss food pyramid; 1 portion/serving=~ 120g.

Table 16: Results of the associations between fruits & vegetables and health outcomes

Reference	Year	Type	Food type	Results	Grade
Cardiovascular disease					
(12)	2019	SR of MA	Dried fruit	A systematic review focusing on the degree of fruit processing and health outcomes, mainly in adult subjects (one of the studies included adolescents), reported no association between dried fruit consumption and CVD risk.	IIA
(4)	2021	R of MA	Fruits	Fruit consumption was associated with inverse coronary heart disease incidence and mortality in various meta-analyses. However, significant heterogeneity was observed between the included studies. A recent dose-response meta-analysis indicated that a consumption of 400 g/day of fruit was associated with reduction in coronary heart disease and CVD incidence and mortality.	IA
(5)	2020	MA	Fruits	Comparing the highest with the lowest fruit intake was associated with lower CVD incidence (RR: 0.91, 95% CI: 0.88-0.95), CVD mortality (RR: 0.88, 95%CI: 0.86-0.91, I^2=79%), CHD incidence (RR: 0.88, 95% CI: 0.84-0.92), CHD mortality (RR: 0.86, 95% CI: 0.82-0.90, I^2=62%), stroke incidence (RR: 0.82, 95% CI: 0.79-0.85), and stroke mortality (RR: 0.87, 95%CI: 0.84-0.91, I^2=75%). Looking at specific fruit sources, highest versus lowest intakes of citrus (9% to 12%) and apples (referred to as “pommes fruit” by the investigators) (10% to 24%) showed significant risk reductions in most CVD outcomes.	IA
(4)	2021	R of MA	Green leafy vegetables and tomatoes	High consumptions (compared to low) of green leafy vegetables and tomatoes were associated with significant reductions in coronary heart disease incidence and cardiovascular disease outcomes.	IA
(4)	2021	R of MA	Vegetables	Significant inverse associations between vegetable consumption and coronary heart disease were reported. The maximum reduction was associated with a consumption of 400 g/day of vegetables.	IA
(5)	2020	MA	Vegetables	Comparing the highest with the lowest vegetable intake was associated with lower CVD incidence (RR: 0.94, 95% CI: 0.90-0.97), CVD mortality (RR: 0.87, 95% CI: 0.85-0.90, I^2=59%), CHD incidence (RR: 0.92, 95% CI: 0.87-0.96, I^2=53%), CHD mortality (RR: 0.86, 95% CI: 0.83-0.89), stroke incidence (RR: 0.88, 95% CI: 0.83-0.93, I^2=50%), and stroke mortality (RR: 0.94, 95% CI: 0.90-0.99, I^2=62%). Consumption of one serving of green leafy vegetables per day was associated with 12% to 18% risk reduction in CVD, CHD, stroke incidence and CHD mortality.	IA
Cancer					
(12)	2019	SR of MA	Dried fruit	A systematic review focusing on the degree of fruit processing and health outcomes, mainly in adult subjects (one of the studies included adolescents), reported no association between dried fruit consumption and cancer risk.	IIA

Reference	Year	Type	Food type	Results	Grade
(12)	2019	SR of MA	Fresh whole fruits	A systematic review focusing on the degree of fruit processing and health outcomes, mainly in adult subjects (one of the studies included adolescents), reported no association between whole fresh fruits consumption and cancer risk.	IIA
Colorectal cancer					
(6)	2021	MA	Citrus fruit	A meta-analysis of cohort and case control studies showed a 10% reduction (95% CI: 0.84-0.96) in colorectal cancer risk with higher citrus fruit intake (I^2=21.6%), compared to lower.	IA
(6)	2021	MA	Cruciferous vegetables	A meta-analysis of cohort and case control studies showed a 10% reduction (95% CI: 0.85-0.95) in colorectal cancer risk with higher cruciferous vegetable intake (I^2=31.02%), compared to lower.	IA
(6)	2021	MA	Garlic	A meta-analysis of cohort and case control studies showed a 17% reduction (95% CI: 0.76-0.91) in colorectal cancer risk with higher garlic intake (I^2=32.64%), compared to lower.	IA
(6)	2021	MA	Tomatoes	A meta-analysis of cohort and case control studies showed a 11% reduction (95% CI: 0.76-0.91) in colorectal cancer risk with higher tomato intake (I^2=0%), compared to lower.	IA
Lung cancer					
(8)	2019	MA	Fruits (Current smokers)	An inverse association (-14% risk; 95% CI: 0.78-0.94) was seen between fruit intake and lung cancer risk in current smokers. Dose-response analysis suggested a non-significant curvilinear correlation in current smokers and lung cancer risk	IA
(8)	2019	MA	Fruits (Former smokers)	An inverse association (-9% risk; 95% CI: 0.84-0.99) was seen between fruit intake and lung cancer risk in former smokers. Dose-response analysis suggested a non-significant curvilinear correlation in former smokers and lung cancer risk.	IA
(8)	2019	MA	Fruits (Never smokers)	A non-statistically significant inverse association between fruit intake and lung cancer risk in never smokers was reported. Between study heterogeneity was reported (I^2=27.2%).	IIA
(8)	2019	MA	Vegetables (Current smokers)	An inverse association was seen between vegetable intake and lung cancer risk in current smokers (summary RR: 87%, 95% CI: 0.78-0.94). The results in current smokers showed some degree of heterogeneity (I^2=25.4%). Dose-response analysis suggested a non-significant curvilinear correlation in current smokers and lung cancer risk.	IIA
(8)	2019	MA	Vegetables (Former smokers)	No association was seen between vegetable intake and lung cancer risk in former smokers. The results in former smokers showed some degree of heterogeneity (I^2=54.3%).	IIA
(8)	2019	MA	Vegetables (Never smokers)	No association was seen between vegetable intake and lung cancer risk in never smokers.	IIA
Cervical cancer					
(13)	2021	MA	Fruits	A 20% (95% CI: 0.70-0.93) decrease in cervical cancer risk was observed in women with the highest intake of fruits, compared to the lowest category. No association was observed when the pooled effect was estimated among studies that adjusted for human papillomavirus (HPV).	IA

Reference	Year	Type	Food type	Results	Grade
(13)	2021	MA	Vegetables	A 40% (95% CI: 0.52-0.73) decrease in cervical cancer risk was observed in women with the highest vegetable intake, compared to the lowest category. No association was observed when the pooled effect was estimated among studies that adjusted for human papillomavirus (HPV).	IA
Liver cancer					
(14)	2021	SR	Fruits	A null association between fruit intake and HCC was reported in a systematic review (including cohort, case-control, and nested-case control studies).	IIB
(7)	2019	MA	Fruits	A null association was reported for higher fruit intake and liver cancer risk (RR: 1.02, 95% CI: 0.89-1.17). Non-significant curvilinear relationship was found, while linear trend was detected for fruit consumption. Dose-response analysis showed no significant reduction per 100 g/day increment in fruit intake.	IIA
(14)	2021	SR	Vegetables	A non-significant inverse association between vegetable intake and HCC was reported in a systematic review (including cohort, case-control, and nested-case control studies). Specific vegetable subgroups were reported to have significant inverse associations, suggesting a protective effect against HCC.	IIA
(7)	2019	MA	Vegetables	A 39% reduction (95% CI: 0.50-0.75) in liver cancer risk was found with higher vegetable intake, with no significant study heterogeneity. Non-significant curvilinear relationship was found, while a linear trend was detected for vegetable consumption. Dose-response analysis showed a 4% (95% CI: 0.95-0.97) reduction in liver cancer risk per 100 g/day increment in vegetable intake.	IA
Gastric cancer					
(9)	2021	MA	Chili peppers	A meta-analysis of 13 case-control studies (four population-based and nine hospital-based) reported on the consumption of chili and its association with gastric cancer. The pooled estimate suggested that moderate-high chili consumption (expressed as daily capsaicin consumption; low: <30 mg/day, moderate-high: 30-250 mg/day) was associated with an almost two-fold higher gastric cancer risk (95% CI: 1.59-2.42; I^2=74.7%). A significant nonlinear association was detected with lower intakes showing a protective effect against gastric cancer, while higher intakes were associated with a higher risk for gastric cancer (OR: 2.28, 95% CI: 1.76-2.96).	IA
Breast cancer					
(12)	2019	SR of MA	Fresh whole fruits	A systematic review of meta-analyses focusing on the degree of fruit processing and health outcomes, mainly in adult subjects (one of the studies included adolescents), reported that consumption of whole fresh fruits was not associated with breast cancer risk.	IIA
Diabetes					
(9)	2020	UR	Fruits	Inconsistent results were reported regarding high fruit intake. Two studies found non-significant benefits of high fruit intake, while one suggested that high fruit intake significantly decreased the risk of T2D (RR: 0.92, 95% CI: 0.86-0.97).	IIA
(15)	2018	MA	Cruciferous vegetables	Higher cruciferous vegetable consumption was inversely associated with T2D (summary RR: 0.87, 95% CI: 0.76-1.00), compared to lower intake. Moderate heterogeneity among studies was reported	IIA

Reference	Year	Type	Food type	Results	Grade
				by the authors (I^2=63.8%). Dose-response analysis reported a 7% (95% CI: 0.85-1.03) decreased risk for T2D with a 40 g/day increment in cruciferous vegetable consumption.	
(15)	2018	MA	Green leafy vegetables	Higher green leafy vegetable consumption (summary RR: 0.91, 95% CI: 0.84-1.00) was inversely associated with T2D while moderate heterogeneity among studies was reported by the authors (I^2=72.3%), compared to lower consumption. Dose-response analysis reported a 3% (95% CI: 0.94-1.00) decreased risk for T2D with a 40 g/day increment in green leafy vegetable consumption.	IIA
(9)	2020	UR	Vegetable	Results suggested that high vegetable intake does not significantly lower the risk of T2D, compared to low vegetable intake.	IIA
Obesity and weight gain					
(12)	2019	SR of MA	Fresh whole fruits	A systematic review of meta-analyses focusing on the degree of fruit processing and health outcomes, mainly in adult subjects (one of the studies included adolescents), reported that consumption of fresh whole fruits was significantly associated with decreased risk of obesity.	IA
(10)	2019	SR	Fruits	Higher fruit intake was associated with a decreased overweight/obesity risk (summary RR: 0.88, 95% CI: 0.80-0.96, I^2=76%).	IA
(16)	2021	UR of SRs	Fruits and vegetables	Studies included in systematic reviews focused on the combined effect of fruit and vegetable intake and obesity. The authors generally concluded that eating more fruits and vegetables may be associated with decreased obesity risk. These results were supported by some, but not all, of the included studies in the systematic reviews.	IIA
(10)	2019	SR	Vegetables	The summary RR for the not statistically significant association between high intake of vegetables and overweight/obesity risk was 0.93 (95% CI: 0.83-1.03, I^2= 66%). The summary RR for overweight/obesity for every 100 g/day vegetable intake was 0.98 (95% CI: 0.93-1.03).	IIA
(12)	2019	SR of MA	Fresh whole fruits	A systematic review of meta-analyses focusing on the degree of fruit processing and health outcomes, mainly in adult subjects (one of the studies included adolescents), reported that consumption of fresh whole fruits was associated with decreases in weight and waist circumference.	IA
(10)	2019	SR	Fruits	The summary RR for high vs. low intake of fruits and weight gain was 0.86 (summary RR: 0.86, 95% CI: 0.70-1.05, I^2=46%). The summary RR for weight gain for every 100 g/day fruit intake was 0.91 (95% CI: 0.86-0.97, I^2=7%)	IIA
(16)	2021	Umbrella review of SRs	Fruits and vegetables	Studies included in systematic reviews focused on the combined effect of fruit and vegetable intake and weight gain. The authors generally concluded that eating more fruits and vegetables may prevent weight gain. These results were supported by some, but not all, of the included studies in the systematic reviews.	IIA
(10)	2019	SR	Vegetables	Intake of vegetables was associated with reduced weight gain risk (summary RR: 0.78, 95% CI: 0.62-0.98, I^2=82%). The summary RR for weight gain for every 100 g/day of vegetable intake was 0.90 (95% CI: 0.81-1.01, I^2=60%).	IA

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review.

2.5.6 References

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2.6 Cereals and starchy foods

Authors: Undine Lehmann. Reviewers: Pedro Marques-Vidal and Esther Infanger

2.6.1 Introduction

The European Food Safety Authority (EFSA) proposes a reference intake range of 45 to 60% of total energy intake for carbohydrates, applicable to both adults and children older than one year of age (1). In the Swiss Food Pyramid, cereal products, potatoes and pulses are combined in one level with a recommendation of 3 portions daily, the cereals preferably as WG (2). However, as pulses are also providing substantial amounts of protein, they are not discussed in this chapter but in the review of protein sources (meat, fish, eggs, vegetable sources) as also recommended in the previous Federal Commission for Nutrition (FCN) report (3). The current review is an update of the expert report of the FCN from 2019 (3).

The term "whole grain" (WG) was defined by different health authorities. Generally, it refers to the intact, ground, cracked or flaked kernel after the removal of inedible parts such as the hull and husk. The principal anatomical components the starchy endosperm, germ and bran are present in the same relative proportions as they exist in the intact kernel (4). However, the term "whole grain food" is not well defined and therefore, studies use different definitions, which makes comparison difficult (1, 4). Grains that are included in the whole grain definition are cereal grasses, wheat, rice, barley, maize, rye, oats, millet, sorghum, teff, triticale, canary seed, Job's tears, and fonio, and the pseudocereals amaranth, buckwheat, quinoa, and wild rice (4, 5). Cereals (i.e. wheat, rye, barley, millet …) and starchy foods (i.e. potatoes, bread, pasta...) contain as main ingredient carbohydrates, the major source of energy in the diet. In addition to their carbohydrate content, cereals and starchy foods are an important source of dietary fibres and micronutrients (3).

2.6.2 Search strategy

We searched the databases PubMed and EMBASE to identify publications about non-communicable diseases (NCD) (cancer, cardiovascular diseases (CVD), diabetes and obesity) and the food groups whole grains, cereals and starchy foods in combination. To identify relevant results we set the following filters: humans, English, publication from 2018 onwards, reviews, systematic reviews and meta-analysis. We were able to identify 42 results (-2 duplicates) for the title and abstract screening, which we imported to systematic Review Tool "Rayyaan". In the following full-text screening, we excluded 26 studies for meeting the exclusion criteria such as "wrong outcome", "wrong food" or "wrong population". At the end of this process, we found 15 eligible studies, which were used for this review. An additional review was retrieved and included after the search. As there were reviews of RCTs available, we did not include single RCTs in the search and evaluation. The syntax is provided in the annex, chapter 2.6.

2.6.3 Main finding

Fifteen reviews and meta-analyses and one evidence mapping review were included in this summary. Compared to the previous expert report of the FCN from 2019 (3), in particular new evidence about the effects of potatoes on health could be retrieved. Evidence was separately evaluated for potatoes, whole grain and refined grains as key foods of the cereals and starchy food group.

2.6.3.1 Cardiovascular disease

A recent systematic review and meta-analysis investigated the association between potato intake and risk of NCD based on 28 studies (6). Total potato consumption showed no associations with coronary heart disease (CHD) (RR: 1.03; 95% CI: 0.96-1.09) or stroke (RR: 0.98; 95% CI: 0.93-1.03) per one daily/serving (150 g/day) increase. Consumption of one daily serving of boiled/baked/mashed-potatoes was not associated with risk of hypertension (RR: 1.08; 95% CI: 0.96-1.21). Positive associations for the risk of hypertension (RR: 1.37; 95% CI: 1.15-1.63) were observed for each 150 g/day increase in French fries' consumption. This rather high amount for French fries consumption was chosen as it facilitated comparison with potatoes. The quality of evidence of this risk association was rated moderate.

An evidence mapping review of 121 observational studies investigated the association between potato consumption and risk of cardiometabolic diseases (7). No association was found between potato intake and CVD incidence, stroke or myocardial infarction or CVD mortality. When studies that reported potato intake as part of a dietary pattern were summarized, all 3 studies found an increase in cardio-metabolic risk factors [e.g., blood insulin, body mass index (BMI)] with dietary patterns that included French fries or potato chips, but not with the dietary pattern that included baked or boiled potatoes (7).

For the association between CVD and whole grain intake, one systematic review compared whole grain, bran and cereal fibre intake in relation with CVD (8). Whole grain intake was associated with lower CVD mortality and lower risk for coronary heart disease. Another systematic review and meta-analysis investigated risk factors for CVD in relation to whole grain or refined grain or placebo consumption in RCTs and found a decrease in certain risk factors for CVD (total cholesterol, low-density lipoprotein cholesterol, triglycerides, haemoglobin A1c, C-reactive protein) after whole grain consumption (9) (not included in **Table 18**).

2.6.3.2 Cancer

One systematic review and dose-response meta-analysis investigated the association between potato consumption and cancer mortality based on 20 cohort studies (10). The association between potato consumption and cancer mortality was nonsignificant (10). Another systematic review and meta-analysis by the same authors investigated the association between potato consumption and site-specific cancers (11). Potato or potato preparations consumption was not associated with multiple cancer sites when comparing high and low intake categories.

Four meta-analyses investigated the association between whole grain intake and either specific cancer (breast (12), bladder (13), gastric (14)) or various site-specific cancer and total cancer mortality (15). The studies showed beneficial effects of whole grain consumption for reduction of cancer risk while for refined grains, evidence was inconclusive.

2.6.3.3 Type 2 Diabetes

Several reviews and meta-analyses showed an increased risk and incidence of type 2 diabetes (T2D) with increased potato intake in a dose-response manner. French fries' or fried potatoes exhibited a stronger detrimental effect (6, 7, 16, 17). In a dose-response meta-analysis of 13 studies, the consumption of fried potato was associated with a 34% increased risk for T2D for each 80 g/day increase, while it was 10% for total potato and 2% for unfried potato (16).

An umbrella review of various dietary factors on the risk of T2D found out that high whole grain intake significantly decreased the risk of T2D, with pooled RR ranging from 0.74 (95% CI: 0.69-0.80) to 0.79 (95% CI: 0.72-0.87). In addition, every 30 g/day increase in whole grain intake significantly reduced the risk of T2D around 13% (pooled RR: 0.87; 95% CI: 0.82-0.93). In contrast to whole grain, high intake of refined grains was not associated with risk of T2D (18).

2.6.3.4 Obesity

One evidence mapping review investigated the effects of potato consumption on obesity or body weight related measures (7). Potato intake increased the risk of obesity in 2 out of 4 studies and increased BMI or body weight in 5 out of 6 studies. When dietary patterns were investigated, patterns which included French fries found an increase in BMI whereas patterns that included baked or boiled potatoes did not find an increase (7).

Three meta-analysis and a systematic review investigated the link between whole grain consumption and body weight related measures. The two systematic review and meta-analysis of RCTs had no agreement. While one review found that whole grain intake was associated with lower body weight in obese/ overweight subjects compared to a control group (19), another review found no effect on body weight or other anthropometric measures (20). A meta-analysis of observational studies and RCTs found a significant, inverse correlation between whole grain intake and BMI in cross-sectional studies, weighted slope, −0.0141 kg/m^2 per g/day of whole grain intake (95% CI: −0.0207, −0.0077; r=−0.526, P=0.0001) but not in RCTs up to 16 weeks (21). A recent systematic review investigated how different methods of reporting and calculating whole grain intake and the applied whole grain definition affect reported associations between whole grain intake and body weight measures (1). It was concluded that studies calculating whole grain intake using total grams of intake, USDA databases, or ≥25% whole grain in combination with listing specific foods, showed consistent beneficial effects of whole grain intake on body weight. Studies with general lists of foods included as “whole grain foods” that are more unspecific or have lower cut-offs for WG content were inconsistent (1).

2.6.4 Conclusion

New evidence indicated that total or unfried potato intake is not associated with CVD or cancer but a slightly higher risk of T2D and weight gain. In contrast, there is strong evidence that fried potato intake is associated with hypertension, T2D and weight gain.

The review revealed new strong evidence for protective effects of WG consumption against cancer. A protective effect against weight gain remains probable when foods rich in whole grain are consumed.

For the food group of ready-to-eat (breakfast) cereals (RTEC), no study met the inclusion criteria for the review. However, there are indications that consumption of RTEC compared to breakfast skipping is associated with higher micronutrient intake in children and adolescents (22). Furthermore, RTEC consumption was associated with higher fibre intake and a healthier eating pattern in children and adolescents but also associated with higher total sugar intake compared to non-RTEC consumers (23). Further studies would be necessary to give conclusive recommendations about this food group and potential differences between different kinds of breakfast cereals (e.g., flakes, muesli, etc.).

Mechanistic explanations about effects of starchy foods on health outcomes remain valid as described in the expert report of the FCN from 2019 (3).

Table 17: Summary cereals and starchy foods and risk of NCD

Conclusion	Class	Level
Potatoes, fried		
Fried potato /French fries intake might increase the risk of CVD	II	A
Fried potato /French fries intake might increase the risk of cancer	II	A
Fried potato /French fries intake increases the risk of diabetes	III	A
Fried potato /French fries intake increases the risk of obesity	III	A
Potatoes, boiled or baked		
Boiled/ baked potatoes intake might increase the risk of CVD	II	A
Boiled/ baked potatoes intake might increase the risk of cancer	II	A
Boiled/ baked potatoes intake might increase the risk of diabetes	II	A
Boiled/ baked potatoes intake increases the risk of obesity	III	A
Whole grain		
Whole grain intake reduces the risk of CVD	I	A
Whole grain intake reduces the risk of cancer	I	A
Whole grain intake reduces the risk of diabetes	I	A
Whole grain intake might reduce the risk of obesity	II	A
Refined grain		
Refined grain intake and risk of CVD	no data	
Refined grain intake might reduce the risk of cancer	II	A
Refined grain intake might reduce the risk of diabetes	II	A
Refined grain intake and risk of obesity	no data	

2.6.5 Recommendations

No new findings were retrieved about the recommended consumption of cereals and starchy foods per day. The recommendation to consume three servings of cereals and starchy foods, as stated in the previous FCN report (3), remains valid. Consumption of free sugars should still be as low as possible

Within the cereal and starchy food group, recommendations about potatoes and cereals as major foods in this group can be made. New evidence indicates that potato intake in fried form is likely to be a risk factor for T2D and increased body weight and consumption should be limited. For boiled, baked or mashed potatoes, the association with detrimental health effects is less strong or inconclusive.

Recent reviews indicated that whole grain intake was protective against CVD, certain cancers, risk for T2D and body weight increase. Added to previous evidence demonstrating protective effects against CVD, the recommendation to consume cereals preferably as whole grain can be confirmed. There is still lack of evidence about a concrete amount of whole grain exhibiting beneficial effects. However, as all available evidence points out that whole grain is more beneficial to health than refined grains, the recommendations to eat preferably whole grain if cereal is consumed can be supported.

Table 18: Estimation of minimum, optimal, and maximum amount of cereals and starchy foods intake in relation to NCD

Food group / NCD	Minimum	Maximum	Optimal
Potatoes, fried			
CVD	-	-	0 g
Cancer	-	-	0 g
T2D	-	80 g/day	0 g
Obesity	-	-	0 g
Potatoes, boiled or baked			
CVD	-	212 g/day	-
Cancer (colorectal)	-	134 g/day §	-
Cancer (all)	-	100 g/day	-
T2D	-	150 g/day	-
Obesity	-	-	-
Whole grain			
CVD	-	-	-
Cancer (all)	30 g/day	-	90 g/day
Cancer (breast)	50 g/day	-	>50 g/day
T2D	30 g/day	-	-
Obesity	-	-	-
Refined grain			
CVD	-	-	-
Cancer	-	-	-
T2D	-	-	-
Obesity	-	-	-

-, not defined; §, for a total potato intake >134 g/day, the risk of CRC increased by ~25% up to ~190 g/day

Table 19: Results of the associations between cereals and starchy foods and health outcomes

Ref.	Year	Study	Food Type	Results	Grade
Cardiovascular disease					
(6)	2019	SR, MA	Potato Fried potato	Total potato intake was not associated with coronary heart disease (CHD) or stroke. Fried potato (French fries) intake (per 150 g/day increase) was associated with increased risk for hypertension	+/- +
(7)	2020	EMR	Potato Fried potato	Most studies found no association between potato intake and CVD or stroke incidence or CVD mortality. Studies that included potato intake as part of dietary patterns analyses reported an increase of all or most cardio-metabolic risk factors and diseases by intake of fried forms of potato.	+/- +
(8)	2019	SR	WG	The highest intake of WG was associated with 12% lower risk of CVD mortality (HR: 0.88; 95% CI: 0.82-0.96, P= 0.001) compared with the lowest intake as well as a 6% lower risk of coronary heart disease (HR: 0.84; 95% CI: 0.71-0.98, P=0.02) when comparing the highest quartile of intake to lowest.	-
Cancer					
(10)	2020	SR and MA	Potato	No significant association was found between potato consumption and risk of cancer (1.09; 95% CI: 0.96-1.24, P=0.204) mortality. In addition, no significant linear association was found between each 100 g/day increments in potato consumption and risk of cancer (P=0.09) mortality. Two of three studies that examined the association of potato consumption with CVD mortality found no significant relationship.	+/-
(11)	2021	SR and MA	Potato	No relation was found between total potato intake (high compared with low intake) and risk of colorectal cancer (CRC), pancreatic cancer, colon, gastric, breast, prostate, kidney, lung, or bladder cancer in cohort or case-control studies. No association between high vs. low intake of potato preparations (boiled/fried/mashed/roasted/baked) and risk of gastrointestinal-, sex-hormone-, or urinary-related cancers in cohort or case-control studies. Certainty of the evidence was low for total cancer, CRC, colon, rectal, renal, pancreatic, breast, prostate, and lung cancer and very low for gastric and bladder cancer.	+/-
(12)	2018	SR and MA	WG	High intake of WG might be inversely associated with a reduced risk of breast cancer, and the inverse association was only observed in case-control but not cohort studies	-
(15)	2020	SR and MA	WG	For total cancer mortality, 7 meta-analyses of cohort studies indicated that WG intake was associated with 6% to 12% lower risk in comparison of highest vs. lowest intake groups, and 3% to 20% lower risk for doses ranging from 15 to 90 g/day. For site-specific cancers, meta-analysis indicated that WG intake was	-

Ref.	Year	Study	Food Type	Results	Grade
				consistently associated with lower risks of colorectal, colon, gastric, pancreatic, and oesophageal cancers. Overall, meta-analyses of cohort and case-control studies consistently demonstrate that WG intake is associated with lower risk of total and site-specific cancer.	
			Refined grain	By contrast, the relationship between refined grain intake and cancer risk is inconclusive.	+/-
(14)	2020	MA	WG	19 studies were included. For WG intake, there was a 13% reduction in the risk of gastric cancer (P=0.003), and a subgroup analysis showed that a large amount of whole grain intake reduced the risk of gastric cancer by 44% (P<0.001).	-
			Refined grain	For refined grain intake, there was a 36% increase in the risk of gastric cancer (P<0.001); a subgroup analysis showed that a large and a moderate amount of refined grain intake increased the risk of gastric cancer by 63% (P<0.001) and 28% (P<0.001), respectively.	+
(13)	2020	MA	WG	Higher intake of total WG was associated with lower risk of bladder cancer (comparing highest with lowest intake tertile: HR: 0.87; 95% CI: 0.77-0.98; HR per 1-SD increment: 0.95; 95% CI: 0.91-0.99; P for trend: 0.023).	-
			Refined grain	No association was observed for intake of total refined grain.	+/-
Diabetes					
(6)	2019	SR, MA	Potato	Consumption of one daily serving of boiled/baked/mashed-potatoes was associated slightly with the risk of T2D (RR: 1.09; 95% CI: 1.01-1.18).	+
			Fried potato	Positive association for the risk of T2D (RR: 1.66; 95% CI: 1.43-1.94) was observed for each 150 g/day increase in French fries consumption. The quality of evidence was rated mostly moderate.	+
(7)	2020	EMR	Potato	4 (50%) studies reported increased T2D incidence associated with potato intake, whereas 2 (25%) reported no difference and 2 (25%) reported a decreased risk.	+
(17)	2020	MA	Potato	Potato intake was associated with risk of T2D.	+
			Fried potato	A linear dose-response analysis indicated that 100 g/day increment of total potato (RR: 1.05; 95% CI: 1.02-1.08) and French fries (RR: 1.10; 95% CI: 1.07-1.14) consumption may increase the risk of T2D by 5% and 10%, respectively	+
(16)	2021	MA	Potato Fried potato	Dose-response meta-analysis demonstrated a significantly increased T2D risk by 10% (95% CI: 1.07-1.14; P for trend<0.001), 2% (95% CI: 1.00-1.04; P for trend=0.02) and 34% (95% CI: 1.24-1.46; P for trend<0.001) for each 80 g/day (serving) increment in total potato, unfried potato, and fried potato intakes, respectively.	+

Ref.	Year	Study	Food Type	Results	Grade
(8)	2019	SR	WG	Whole grain intake was associated with a 21% (95% CI: 0.65-0.96, P=0.0089) to 35% (95% CI: 0.36-1.18, P= 0.02) lower risk of T2DM comparing the highest to the lowest intake group.	-
(18)	2020	UR	WG	High WG intake significantly decreased the risk of T2D with pooled RR ranging from 0.74 (95% CI: 0.69-0.80) to 0.79 (95% CI: 0.72-0.87). In addition, every 30 g/day increase in WG intake significantly reduced the risk of T2D around 13% (pooled RR: 0.87; 95% CI: 0.82-0.93).	-
			Refined grain	In contrast to WG, high intake of refined grains was not associated with risk of T2D.	+/-
Obesity					
(7)	2020	EMR	Potato	Most studies found an increased BMI or body weight with higher potato intake (preparation type not differentiated, in some studies irrespective of type).	+
(21)	2019	MA	WG	Cross-sectional data meta-regression results indicate a significant, inverse correlation between WG intake and BMI. Prospective cohort results generally showed inverse associations between WG intake and weight change with typical follow-up periods of five to 20 years. Higher WG intake is significantly inversely associated with BMI in observational studies but not RCTs up to 16 weeks in length.	-
(8)	2019	SR	WG	WG intake was associated with better weight management over time. For every 40 g/day increase in WG intake, 8-year weight gain was 1.1 kg lower (P<0.0001).	-
(19)	2020	SR and MA	WG	Review of 22 RCTs in obese/ overweight subjects. WG intake was associated with lower body weight compared to a control group but there was no difference in WC or risk factors for CVD.	-
(20)	2020	SR and MA	WG	Review of 21 RCTs. No significant effect of WG intake on body weight, BMI, body fat percentage or WC.	+/-
(1)	2021	SR	WG	Many cross-sectional studies showed WG intake was, to some degree, significantly associated with body weight measures, whereas associations varied greatly among cohort studies. Studies calculating WG intake using total grams of intake, USDA databases, or ≥25% whole grain in combination with listing specific foods, showed consistent beneficial effects of increasing WG intake on body weight. Studies with general lists of foods included as "whole grain foods" or lower cut-offs for WG content were inconsistent. The majority of studies reported WG intake as servings/day or grams whole grain/day. This review suggests that an association between whole grain and body weight measures remains likely.	+

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review; WG, whole grain. Summary result: + positive association between consumption and health outcome; +/- no association; - neg. association (inverse/ protective)

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2.7 Meat, fish and eggs

Authors: Sabine Rohrmann Reviewer: Beatrice Baumer

2.7.1 Introduction

Meat is a food rich in protein, minerals such as iron and zinc as well as a variety of vitamins, in particular B vitamins. Depending on the type of meat, i.e., red meat (beef, pork, sheep etc.) versus white meat (mainly poultry), however, the content of cholesterol and saturated fat is higher than in some other food groups. Processed meat, defined as products usually made of red meat, but also of poultry, that are cured, salted or smoked (e.g., ham or bacon) in order to improve the shelf life, but also colour and taste. These products also often contain a high amount of minced fatty tissue (e.g., sausages). Hence, high consumption of processed meats and to a certain extend also unprocessed red meat may lead to an increased intake of saturated fats, cholesterol, salt, nitrite, haem iron, polycyclic aromatic hydrocarbons, and-depending upon the chosen food preparation method-also heterocyclic amines (1).

Fish are considered a healthy food given its high content of high-quality protein and, in fatty fish, a higher content of long-chain n-3 fatty acids (2). However, the consumption of certain types of fish is associated with a higher intake of mercury and other heavy metals. Indeed, the consumption of saltwater fish and other seafood containing methylmercury is a leading source of mercury exposure (3).

Eggs, in particular egg yolk, are rich in cholesterol and have therefore long been linked with an increased risk of CVD. However, the role of dietary cholesterol in the aetiology of CVD has been disputed in the past years, also given the fact that eggs are a source of vitamins, minerals, and high-quality protein (4).

2.7.2 Search strategy

A systematic search was conducted to find publications. The syntax is provided in the annex, chapter 2.7. If no relevant literature was found by the systematic search, a “free” search in PubMed was conducted. This free search led to some additional reviews on the topic that were also included in this review.

2.7.3 Main findings

The German Nutrition Society (DGE) conducted an umbrella review on the health effects of meat consumption in their 2020 scientific report (5). Although positive associations of a high red and processed meat consumption were observed for CVD, T2D and colorectal cancer, the level of evidence was general considered very low to low, with some exceptions of moderate evidence (Table 21). DGE only evaluated the evidence for colorectal and breast cancer, but no other cancer outcomes. Some publications evaluated other cancer outcomes (6, 7)**,** but only the World Cancer Research Fund / American Institute of Cancer Research (WCRF/AICR) evaluated a larger number of cancer outcomes systematically (8). They concluded that there was convincing evidence of a positive association between processed meat consumption and risk of colorectal cancer and probable evidence for an association of red meat consumption with colorectal cancer risk. Although other systematic reviews come up with the same associations, they rate the evidence for an association of meat consumption with colorectal cancer as lower compared with WCRF/AICR (9) given that fact that this evidence is based on observational studies only. Positive associations of high red and processed meat consumption were also seen for T2D (with low level of evidence). Only few prospective studies are available to evaluate the association of meat consumption with obesity.

In contrast to red and processed meat, white meat is generally not associated with increased risk of CVD, cancer, or T2D (see **Table 22**).

Fish consumption has less frequently been studied in association with the risk of chronic diseases (**Table 23**). CVD mortality was observed to be inversely associated with fish consumption (7)**.** WCRF/AICR concluded that limited evidence is available for a decreased risk of liver cancer with higher fish consumption (see also (6)), but there was no evidence for any other cancer type (8). The associations with T2D and obesity tend to be quite heterogeneous and based on a small number of studies.

The association of **egg consumption** with risk of cardiovascular diseases appears to depend on the amount of eggs consumed and the outcome (**Table 24**). Similarly, the associations for T2D are rather heterogeneous and the quality of evidence is considered low. WCRF/AICR did not draw any conclusion on the association between egg consumption and cancer risk because of too few, too small or too inconsistent results (8). No associations with obesity were observed; however, the number of prospective studies is limited.

2.7.4 Conclusion

2.7.4.1 Conclusions of the previous reports

The 2014 FCN report on meat concluded that consumption of unprocessed red meat and processed was associated with an increased risk of NCD, and more specifically of CVD, cancer and T2D (10). This conclusion remains supported by the recent scientific literature, and several nutritional agencies recently made specific recommendations. With respect to fish consumption, the previous report adopted the recommendations of WCRF/AICR (i.e., no recommendation for fish regarding cancer prevention, but WCRF/AICR mention recommendations for the prevention of other NCD [one to two times/week, one of which should be a fatty fish]). No conclusions on egg consumption were drawn.

The 2019 FCN report agreed with these conclusions, but added that more attention should be paid to a diversification of protein sources, including proteins of plant origin. This pyramid level should be revised as soon as more data is available for proteins from alternative sources (e.g. insects, bio-engineered meat, and other novel food items derived from cellular agriculture).

2.7.4.2 Conclusion of the current report

There is large evidence, though based on observational studies, that a high consumption of red and processed meat increases the risk of CVD, colorectal cancer and T2D. The evidence for other types of cancer is positive for some, but rather limited. No convincing association are seen for obesity.

Results for fish and egg consumption are rather heterogeneous and no firm conclusions can be drawn besides an inverse association between fish consumption and risk of CVD. For egg consumption, results are rather inconsistent, with uncertainties for the amount of eggs consumed and differences in results when looking at CHD and stroke.

Table 20: Summary meat, fish and eggs intake and risk of NCD

Conclusion	Class	Level
Red meat		
Increasing consumption of red meat increases the risk of CVD	III	A
Increasing consumption of red meat increases the risk of cancer	II/III	A
Increasing consumption of red meat increases the risk of T2D	III	A
Increasing consumption of red meat might increase the risk of obesity	II	A
Processed meat		
Increasing consumption of processed meat increases the risk of CVD	III	A
Increasing consumption of processed meat increases the risk of cancer	II/III	A
Increasing consumption of processed meat increases the risk of T2D	III	A
Increasing consumption of processed meat might increase the risk of obesity	II	A
White meat		
Increasing consumption of white meat might decrease the risk of CVD	II	A
Increasing consumption of white meat might decrease the risk of cancer	II	A
Increasing consumption of white meat might decrease the risk of T2D	II	A
Increasing consumption of white meat might decrease the risk of obesity	II	A
Fish		
Increasing consumption of fish decreases the risk of CVD	I	A
Increasing consumption of fish might decrease the risk of cancer	II	A
Increasing consumption of fish might decrease the risk of T2D	II	A
Increasing consumption of fish might decrease the risk of obesity	II	A
Eggs		
Increasing consumption of eggs might decrease the risk of CVD	II	A
Increasing consumption of eggs might decrease the risk of cancer	II	A
Increasing consumption of eggs might decrease the risk of T2D	II	A
Increasing consumption of eggs might decrease the risk of obesity	II	A

2.7.5 Recommendations

Table 21: Estimation of minimum, optimal, and maximum amount of red meat, processed meat, fish, and egg intake in relation to NCD

Food group/ NCD	Minimum	Maximum	Optimal
Red meat			
CVD	0 g/day	100 g/day	40 g/day
Cancer (colorectal)	0 g/day	50 g/day	0 g/day
T2D	every 100 g/day increase in intake of red meat significantly increased the risk of T2D with pooled RRs of 1.17 (95% CI: 1.08-1.26)		
Obesity	0 g/day	100 g/day	0 g/day
Processed meat			
CVD	0 g/day	0 g/day	0 g/day
Cancer (colorectal)	0 g/day	0 g/day	0 g/day
T2D	every 50 g/day increase in intake of processed meat significantly increased the risk of T2D with pooled RRs of 1.37 (95% CI: 1.22-1.55)		
Obesity	0 g/day	0 g/day	0 g/day
White meat			
CVD	-	-	-
Cancer	-	-	-
T2D	-	-	-
Obesity	-	-	-
Fish			
CVD	>0 g/day	90 g/day	50 g/day
Cancer	-	-	-
T2D	-	-	-
Obesity	-	-	-
Eggs			
CVD	0	5 per day	1 per day
Cancer	-	-	-
T2D	1 per week	2 per week	1 per week
Obesity	-	-	-

-, not reported.

Table 22: Results of the associations between meat consumption and health outcomes

Ref	Year	Type	Food type	Results	Grade
Cardiovascular disease					
(11)	2019	SR/MA: Cohort studies that included over 1000 adults	Processed and unprocessed meat	Low-certainty evidence was found that a reduction in unprocessed red meat intake of 3 servings per week is associated with a very small reduction in risk for CVD mortality, stroke, and myocardial infarction. Likewise, low-certainty evidence was found that a reduction in processed meat intake of 3 servings per week is associated with a very small decrease in risk for cardiovascular mortality, stroke, and myocardial infarction.	IIIA
(9)	2019	SR/MA: PCS including over 1000 adults	Dietary patterns low in red and processed meat	Dietary patterns low in red and processed meat intake result in very small or possibly small decreases in cardiovascular mortality, nonfatal coronary heart disease, and fatal and nonfatal myocardial infarction.	IIIA
(12)	2019	SR of RCTs	RCTs comparing diets low vs. high in red meat differing by a gradient of ≥1 serv/week for ≥6 months	Of 12 eligible trials, a single trial enrolling 48 835 women provided the most credible, though still low certainty, evidence that diets lower in red meat may have little or no effect on cardiovascular mortality (HR: 0.98; 95% CI: 0.91-1.06), and CVD (HR: 0.99; 95% CI: 0.94-1.05).	IIA
(5)	2020	UR	Total red meat	Positive association in 5 MAs for stroke; low evidence Positive association in 1 MA for CHD; low evidence	IIIA
(5)	2020	UR	Red meat	Positive association in 7 MAs for stroke; 1 MA with no association; very low to moderate evidence (mostly low) Positive association in 1 MA for CHD; 1 with no association; very low to low evidence	II/IIIA II/IIIA

Ref	Year	Type	Food type	Results	Grade
(5)	2020	UR	Processed meat	Positive association in 5 MAs for stroke; 1 MA with no association; very low to moderate evidence (mostly low) Positive association in 2 MAs for CHD; very low to low evidence	II/IIIA IIIA
(5)	2020	UR	White meat	No or an inverse association with stroke risk (2 MAs); moderate evidence	IIA
(13)	2021	MA of PCS	White meat	When comparing the highest versus the lowest consumption of white meat, the pooled OR and pertinent 95% CI were 0.95 (0.89-1.01, p=0.13, n=10) for CV mortality, and 0.99 (0.95-1.02, p=0.48; n=10) for non-fatal CV events.	IIA
Cancer					
Colorectal cancer					
(5)	2020	UR	Total red meat	Positive association in 1 MA; low to moderate evidence	IIIA
(5)	2020	UR	Red meat	Positive association in 3 MAs; low to moderate evidence	IIIA
WCRF (included in (5))	2018	SR/MA	Red meat	Probable evidence for a positive association with colorectal cancer	IIIA
(5)	2020	UR	Processed meat	Positive association in 3 MAs; low to moderate evidence	IIIA
WCRF (included in (5))	2018	SR/MA	Processed meat	Convincing evidence for a positive association with colorectal cancer	IIIA
(5)	2020	UR	White meat	No association in 1 MA; very low evidence	IIA
Breast cancer					
(5)	2020	UR	Total red meat	No association in 3 MAs; very low to moderate evidence	IIA

Ref	Year	Type	Food type	Results	Grade
(5)	2020	UR	Red meat	No association in 3 MAs; positive association in 1 MA; low to moderate evidence	IIA
WCRF (included in (5))	2018	SR/MA	Red meat	No evidence for a positive association with breast cancer	IIA
(5)	2020	UR	Processed meat	Positive association in 3 MAs; no association in 1 MA; low to moderate evidence	II/IIIA
WCRF (included in (5))	2018	SR/MA	Processed meat	No evidence for a positive association with breast cancer	IIA
(14)	2018	MA, PCS	Red & processed meat	On MA, processed meat consumption was associated with overall (relative risk [RR] 1.06; 95% CI: 1.01-1.11, n=10) and post-menopausal (RR: 1.09; 95% CI: 1.03-1.15, n=6), but not pre-menopausal (RR: 0.99; 95% CI: 0.88-1.10, n=6) breast cancer. No statistically significant associations with red meat consumption.	IIIA
(15) (included in (5))	2018	SR/MA, PCS	Red & Processed meat	Comparing the highest to the lowest category, red meat (unprocessed) consumption was associated with a 6% higher breast cancer risk (pooled RR,1.06; 95% CI: 0.99-1.14; I2=56.3%, n=13 studies), and processed meat consumption was associated with a 9% higher breast cancer risk (pooled RR: 1.09; 95%CI: 1.03-1.16; I2=44.4%, n=15)	IIA IIIA
(5)	2020	UR	White meat	No association in 2 MAs; low to moderate evidence	IIA
Bladder cancer					
(16)	2021	Pooled analysis	Meat	An increased BC risk was found for high intake of organ meat (HR comparing highest with lowest tertile: 1.18; 95% CI: 1.03-1.36, p-trend=0.03). No statistical significant associations with total, red, or processed meat or poultry.	IIA
Hepatocellular cancer					
(6)	2021	SR	White, red, processed meat	Higher contribution to total calorie intake from processed red meat (comparing highest to lowest tertile intake) indicated an 84% increased HCC risk (HR=1.84; 95% CI: 1.16-2.92, p=0.04). Conversely, higher intake (3.5 servings/week) of white meat demonstrated a 39% lower risk of HCC (comparing highest to lowest tertile intake, HR=0.61; 95% CI: 0.40-0.91,	IIA IA

Ref	Year	Type	Food type	Results	Grade
				p=0.02) and a protective association (HR=0.52; 95% CI: 0.36-0.77) with HCC incidence. The Nurses' Health Study (NHS) and Health Professionals Follow-up Study (HPFS) further examined the type of white meat (i.e., poultry) intake, reporting a significantly protective association (HR=0.60; 95% CI: 0.40-0.90, p=0.01) with HCC. However, some studies did not report any association.	
Incidence and mortality					
(17)	2019	SR/MA: PCS including over 1000 adults	Processed and unprocessed meat	Low-certainty evidence suggested that an intake reduction of 3 servings of unprocessed meat/week was associated with a very small reduction in overall cancer mortality over a lifetime. Evidence of low to very low certainty suggested that each intake reduction of 3 servings of processed meat/week was associated with very small decreases in overall cancer mortality over a lifetime; prostate cancer mortality; and incidence of oesophageal, colorectal, and breast cancer.	IIIA
Various cancers					
(8)	2018	SR/MA	Processed meat	Limited evidence for a positive association with nasopharynx, oesophagus, lung, stomach (non-cardia), pancreas	IIA
(8)	2018	SR/MA	Red meat	Limited evidence for a positive association with nasopharynx, lung, pancreas	IIA
(9)	2019	SR/MA: PCS including over 1000 adults	Dietary patterns low in red and processed meat	Dietary patterns low in red and processed meat intake result in very small or possibly small decreases in cancer mortality and incidence.	IIA
(12)	2019	SR of RCTs	RCTs comparing diets low vs. high in red meat differing by a gradient of ≥1 serv/week	Of 12 eligible trials, a single trial enrolling 48,835 women provided low- to very-low-certainty evidence that diets lower in red meat may have little or no effect on total cancer mortality (HR: 0.95; 95% CI: 0.89-1.01) and the incidence of cancer, including colorectal cancer (HR: 1.04; 95% CI: 0.90-1.20) and breast cancer (HR: 0.97; 95% CI: 0.90-1.04).	IIA

Ref	Year	Type	Food type	Results	Grade
			for ≥6 months		
Diabetes					
(5)	2020	UR	Total Red meat	Positive association in 2 MAs for stroke; very low to low evidence	IIIA
(5)	2020	UR	Red meat	Positive association in 4 MAs; 1 MA with no association; low to high evidence (1 low, 2 moderate, 2 high)	IIIA
(5)	2020	UR	Processed meat	Positive association in 5 MAs; low to high evidence (1 low, 2 moderate, 2 high)	IIIA
(18)	2020	UR	Red and processed meat	Two SRMAs of cohort studies. High intake of red and processed meat significantly increased the risk of T2D with pooled RR of 1.21 (95% CI: 1.13-1.30) for red meat and pooled RR ranging from 1.27 (95% CI: 1.20-1.35) to 1.41 (95% CI: 1.25, 1.60) for processed meat. In addition, every 100 g/day increase in intake of red meat and 50 g/day increase in intake of processed meat also significantly increased the risk of T2D with pooled RRs of 1.17 (95% CI: 1.08-1.26) and 1.37 (95% CI: 1.22-1.55), respectively.	IIIA
(11)	2019	SR/MA: Cohort studies that included over 1000 adults	Processed and unprocessed meat	Low-certainty evidence was found that a reduction in unprocessed red meat intake of 3 servings/week is associated with a very small reduction in risk for T2D. Likewise, low-certainty evidence was found that a reduction in processed meat intake of 3 servings/week is associated with a very small decrease in risk for T2D.	IIIA
(9)	2019	SR/MA: Cohort studies that included over 1000 adults	Dietary patterns low in red and processed meat	Dietary patterns low in red and processed meat intake result in very small or possibly small decreases in T2D.	IIIA
(5)	2020	UR	White meat	No or an inverse association with stroke risk (2 MAs); moderate evidence	IIA

Ref	Year	Type	Food type	Results	Grade
Obesity					
(19)	2019	SR/MA	Red meat	Positive associations of red meat intake with general obesity and abdominal obesity; non-statistically significant positive association with weight gain. Very small number of prospective studies.	IIA
(19)	2019	SR/MA	Processed meat	Positive associations of red meat intake with general obesity, abdominal obesity, and weight gain. Very small number of prospective studies.	IIA

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review.

Table 23: Results of the associations between fish consumption and health outcomes

Ref.	Year	Type	Food type	Results	Grade
Cardiovascular disease					
(7)	2021	MA	Fish	The results indicated that the fish consumption was inversely associated with the CVD mortality risk (RR: 0.91; 95% CI: 0.85-0.98).	IA
Cancer					
Overall					
(8)	2018	SR/MA	Fish	Limited evidence for a decreased risk of liver cancer with higher fish consumption; no evidence for any other cancer type	IIA
Bladder cancer					
(16)	2021	Pooled analysis of 11 studies	Fish	A marginally inverse association was observed for total fish intake and bladder cancer risk among men (HR comparing highest with lowest tertile: 0.79; 95% CI: 0.65-0.97, p-trend=0.04), but not in women	I/IIB
Hepatocellular cancer					
(6)	2021	SR	Fish	Greater consumption of fish was associated with reduced risk of hepatocellular cancer. Each 20 g/day fish consumption correlated with a reduction in HCC development (HR: 0.80; 95% CI: 0.69-0.97). The EPIC and, NHS and HPFS studies reported that substituting 20 g/day in place of fish for meat resulted in a 16% decrease in HCC risk, and substitution of poultry or fish for processed red meat was associated with a decrease in risk of HCC (HR: 0.79; 95% CI: 0.61-1.02).	I/IIB
Diabetes					
(20)	2021	Federated MA	Fish	In women, for each 100 g/week higher intake the IRRs (95% CIs) of T2D were 1.02 (95% CI: 1.01-1.03, I^2=61%) for total fish, 1.04 (95% CI: 1.01-1.07, I^2=46%) for fatty fish, and 1.02 (95% CI: 1.00-1.04, I^2=33%) for lean fish. In men, all associations were null.	II/IIIA

Ref.	Year	Type	Food type	Results	Grade
(18)	2020	UR	Fish	Results from three SRMAs did not reflect the benefit of high fish intake in lowering the risk of T2D. Finding from dose response analysis also indicate the non-significant benefit of regular consumption of fish in prevention of T2D. Quality was considered critically low.	IIA
(21)	2019	UR	Fish	No statistically significant association between consumption of total fish/seafood; fish; lean fish; or shellfish with risk of T2D. Quality of evidence was considered low.	IIA
Obesity					
(19)	2019	SR/MA	Fish	Results on the association between fish consumption were very heterogeneous, depending on outcome: inverse association with abdominal obesity, but positive association with weight gain.	IIA

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review.

Table 24: Results of the associations between egg consumption and health outcomes

Ref	Year	Type	Food type	Results	Summary
Cardiovascular disease					
(22)	2019	MA	Eggs	No statistically significant association of egg consumption with coronary heart disease mortality (n=6; HR: 1.23; 95% CI: 0.89-1.72), but there was an inverse association with stroke mortality (n=8; HR: 0.72; 95% CI: 0.54-0.96).	I/IIA
(23)	2019	MA	Eggs	The updated MA showed that 7+ eggs/week was not associated with IHD (n=13; HR: 0.97; 95% CI: 0.90-1.05) but associated with a small reduction in stroke (n=14; HR: 0.91; 95% CI: 0.85-0.98).	IIA
(24)	2021	Dose-response MA	Eggs	17 datasets from 14 studies conducted on CVD. Intake of up to 6 eggs/week is inversely associated with **CVD** events, when compared to no consumption [SRR: 0.95; 95% CI: 0.90-1.00]; a decreased risk of CVD incidence was observed for consumption of up to 1 egg per day [SRR: 0.94; 95% CI: 0.89-0.99]. The summary analysis for **CHD** incidence/mortality (24 datasets from 16 studies) showed a decreased risk up to 2 eggs/week (SRR: 0.96; 95% CI: 0.91-1.00). No associations were retrieved for **stroke**. After considering GRADE criteria for strength of the evidence, it was rated low for all outcomes but stroke, for which it was moderate (yet referring to no risk).	IIA
(25)	2021	Pooling study (9 PCS)	Eggs	Overall, egg consumption was not associated with the risk of CHD. In a sensitivity analysis, there was a 30% higher risk of CHD (95% CI: 3%-56%) restricted to older adults consuming 5-6 eggs/week	IIB
Cancer					
General					
(8)	2018	MA/SR	Eggs	Data were either of too low quality or too inconsistent, or the number of studies too few, to allow conclusion to be reached.	IIA/C
Upper aero-digestive tract					
(26)	2019	MA	Eggs	38 studies incl. 32 case-control studies. 42% increased risk of upper aero-digestive tract cancers among those with the highest egg consumption compared to those with the lowest intake (95% CI: 1.19-1.68). Only evident in hospital-based case-control studies, but not in population-based case-control studies and not in prospective cohort studies (OR 0.86; 95% CI: 0.71-1.04).	II/IIIA

Ref	Year	Type	Food type	Results	Summary
Diabetes					
(27)	2020	MA	Eggs	22 risk estimates. Using random effects dose-response MA, the pooled RR of T2D associated with a 1 egg/day increase was 1.07 (95% CI: 0.99-1.15). A 1 egg/day increase in consumption was associated with a higher risk of T2D among US studies (RR: 1.18; 95% CI: 1.10-1.27; I^2=51.3%), but not among European (RR: 0.99; 95% CI: 0.85-1.15; I^2=73.5%) or Asian (RR: 0.82; 95% CI: 0.62-1.09; I^2=59.1%) studies. Still, there was evidence of moderate to substantial heterogeneity within each geographic stratum.	IIA
(18)	2020	UR	Eggs	Results from one SRMA of cohort studies suggest that high intake of egg did not significantly decrease the risk of T2D. Quality was considered critically low.	IIA
(25)	2021	Pooling study (9 PCS)	Eggs	While egg consumption up to one per week was not associated with T2D risk, consumption of ≥2 eggs/week was associated with elevated risk [27% elevated risk of T2D comparing 7+ eggs/week vs. none (95% CI: 16%-37%)]. There was little evidence for heterogeneity across cohorts.	IIB
Obesity					
(19)	2019	SR/MA	Eggs	No statistically significant association with abdominal obesity (1 study) and a positive association with weight gain (1 study)	IIA

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review.

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2.8 Milk and dairy products

Author: Nicole Bender Reviewer: Suzanne Suggs

2.8.1 Introduction

Milk and dairy products are rich in many nutrients like protein, vitamins A and B_{12}, calcium, potassium, magnesium, and zinc. Fermented milk products contain probiotic microorganisms that interact with the gut microbiome (1). However, the association between milk and dairy products with different health outcomes is not uniform. Depending on the type of dairy, as well as on the type of outcome, the association was found to be positive, neutral, or negative in the previous expert report of the Federal Committee for Nutrition in 2019 (2). Overall, the report found no evidence for a detrimental effect of milk and dairy products on health, with exception of a positive association between dairy products and risk of prostate cancer. Several associations between specific dairy types and specific outcomes were neutral or even protective, but the evidence was often weak. Since this report, several studies on the association between dairy products and health outcomes were published, including randomized controlled trials, systematic reviews, and meta-analyses.

Here we updated the report focusing on the outcomes cardiovascular diseases (CVD) (myocardial infarction, stroke, and CVD specific mortality), diabetes type II, all types of cancer, and obesity (incl. weigh loss). We did not include all-cause mortality, but the disease outcomes described and the disease specific mortalities correlate with all-cause mortality as well. We included the dairies milk, cheese, yoghurt, curd, kefir, and cottage cheese. We differentiated between different dairy fat levels if possible.

2.8.2 Search strategy

We composed a search strategy for the databases PubMed and EMBASE, including terms on the intervention (“milk”, “dairy”, “cheese” etc.), and the outcomes (“cancer”, “cardiovascular system”, “diabetes”, etc.) formulated as MeSH terms and as free text. We applied filters for human subjects, adult population, English language, publication years 2018-2021, and study design (review, systematic review, meta-analysis, RCT). The syntax is provided in the annex. Search date was the 10. August 2021. The retrieved references were downloaded in the reference software Endnote, deduplicated and imported in the online review software Rayyan for title and abstract screening. The screening was performed by two independent reviewers. We retrieved 33 full-text articles for full-text screening, and finally included 30 studies in the review. Several articles provided information on more than one outcome.

2.8.3 Main findings

2.8.3.1 Cardiovascular diseases

The three systematic reviews and four narrative reviews reported mostly on unclear to conflicting associations between different dairies and CVD outcomes. However, a protective effect seems to exist especially for stroke and cerebrovascular mortality (3-6), and a protective effect seems to come from yoghurt (3, 6, 7).

2.8.3.2 Cancer

The seven systematic reviews and meta-analyses, and the four narrative reviews showed a diverse pattern of results depending on the type of cancer. There seems to be some evidence for a protective effect, especially of low-fat dairies and yoghurt, on colorectal cancer (8-12), bladder cancer (13), breast cancer (14), and oropharyngeal cancer (15). There seems to be further evidence for the detrimental association with prostate cancer (12, 16) and endometrial cancer (12). One review reported about two cohort studies showing an association between a higher total dairy intake with a statistically significant higher risk of hepato-cell carcinoma (HCC), while yoghurt consumption was associated with a lower risk. However, other cohorts did not confirm these associations (17).

2.8.3.3 Diabetes

The three meta-analyses, three randomized controlled trials, and two narrative reviews reported mainly unclear results on the association between dairy intake and diabetes, especially the rather short lasting RCTs. In the cohort studies summarized in the meta-analyses and the reviews, however, it seemed that dairy in general (18, 19) and especially yoghurt had a protective effect on diabetes (3, 6, 20). An RCT in an Indian population, however, showed positive associations between dairy intake and blood glucose values in diabetic and normoglycaemic individuals (21).

2.8.3.4 Obesity

The two meta-analyses, eight RCTs and two narrative reviews show little evidence for a weight lowering effect of milk or dairy products overall. However, if included in calorie-restricted diets, dairies seem to additionally contribute to weight loss (3, 22-27). Interestingly, there seems to be no difference between low and high-fat dairies in this effect.

2.8.4 Conclusion

The evidence for the associations between milk and dairy intake and health outcomes vary by type of dairy and type of outcome. Most results are still conflicting or unclear, probably due to heterogeneity of study designs and populations assessed, as well as to confounding. However, a picture emerges showing that milk and dairies might have beneficial effects on cerebrovascular health, diabetes type II, body weight, several cancers, and especially colorectal cancer. The potentially detrimental effect already observed in the 2019 report for prostate cancer seems to be further confirmed, and other cancers such as endometrial cancer should be assessed for potentially negative associations with dairy consumption. From the present studies it was also clear that the results differed by type of dairy, and the role of fermented products deserve more attention, especially yoghurt. In future studies it is important to discern which dairies were consumed, at which quantities, and at which fat level. However, at the moment, there is no scientific evidence for dairy recommendations by fat-level. The former recommendation to diversity the intake of dairy products can still be maintained, with a restriction for sweetened dairies, as there is no advantage over unsweetened versions known to date.

Table 25: Summary dairy intake and risk of NCD

Conclusion	**Class**	**Level**
Milk and dairy, especially yoghurt, might reduce the risk for strokes and CVD	II	A
Milk and dairy, especially yoghurt, might have a protective effect on several cancers, especially colon, oropharyngeal and bladder cancer	II	A
Milk and dairy increase the risk for prostate cancer	III	A
Milk and dairy (except yoghurt) might increase to a weaker extend the risk of some other cancers such as hepatocellular carcinoma	II	A
Milk and dairy, especially yoghurt, might have a protective effect on T2D	II	A
Milk and dairy might reduce weight, but only within a weight-reducing diet	II	A

2.8.5 Recommendations

Table 26. Estimation of minimum, optimal, and maximum daily amount for consumption of milk and dairy products in relation to NCD

Food group	NCD	Minimum	Maximum	Optimal
Milk and yoghurt	Stroke	400 g §; RR between 0.92 and 0.98 per increment of 200 g (for yoghurt 100 g) §	-	-
Total dairy	Colon cancer	400 g §	-	-
Milk/fermented milk	Colon cancer	200 g §	-	-
Cheese	Colon cancer	50 g §	-	-
Milk	Bladder cancer	227 mL §	-	-
Whole milk	Bladder cancer	-	220 g §	
Fermented dairy	Bladder cancer	67 g §	-	-
Yoghurt	ER-breast cancer	60 g §	-	-
Cottage cheese	ER-breast cancer	25 g §	-	-
Dairies	Insulin resistance	3-5 servings #	-	-
Total dairy	T2D	270 g §	-	-
Yoghurt	T2D	100 g §; RR 0.94 per increment of 100 g §	-	-
Cheese	T2D	-	40 g §	-
Low fat milk	T2D	200 g §	-	-
Low fat dairies	Obesity	4-5 servings #	-	-
Low fat milk	Obesity	200 ml #	-	-
Dairies within diets	Obesity	2-4 servings #	-	-

§ cohort studies; # randomized controlled trials; ER: oestrogen receptor; -, not reported. 1 Serving of dairies corresponds to: milk/yoghurt: 8 oz./237 ml, cheese: 42.5 g. The given values showed a decrease (in the Minimum colon) or increase (in the Maximum column) in disease risk in the indicated studies. Only studies with quantitative indications are given, the list is therefore not complete.

Table 27: Results of the associations between dairy and health outcomes

Ref.	Year	Type	Food type	Results	Grade
Cardiovascular disease					
(4)	2021	SR / MA	Milk, yoghurt, cheese	3 studies (163,128 participants, 3,691 cases) were included. Comparing the highest with the lowest category of milk intake, a lower risk of ischemic stroke was observed (RR: 0.88; 95% CI 0.79-0.98). For yoghurt and cheese, no associations were observed.	IIA
(5)	2019	MA	Dairy, Milk	In a data set of 24,474 participants, 3520 deaths occurred during follow-up. A negative association between total dairy (HR: 0.96; 95% CI: 0.94-0.98) and milk consumption (HR: 0.93; 95% CI: 0.91-0.96) with risk of cerebrovascular mortality was found. Milk consumption was associated with increased CHD mortality (HR: 1.04; 95% CI: 1.02-1.06).	IIB
(7)	2021	SR / MA	Dairy / fermented dairies	Six meta-analyses: no overall association between dairies or milk with cardiovascular outcomes, no associations if divided up by fat content. Several studies including meta-analyses reported an inverse association of fermented dairies such as yoghurt and cheese and cardiovascular outcomes with risk reductions of 12-18%.	IIA
(11)	2020	NR	Dairy	Milk and dairy products, if not consumed in high daily quantities, can have a positive effect on cardiovascular health.	IC
(12)	2020	NR	Dairy	In a large cohort of women, full-fat and low-fat dairy products had similar associations to CHD risk; lower risk than that of red meat but higher risk than that of fish or nuts. A similar risk of stroke was seen between the sexes. No clear association between total dairy consumption and risk of CVD. In prospective cohort studies, no clear association between whole milk or low-fat milk with the incidence or mortality of CHD or stroke.	IIB
(3)	2020	NR	Dairy	The consumption of milk and yoghurt was associated with a reduced risk of stroke: total dairy 0.98 (0.96-1.01), ns; low-fat dairy 0.97 (0.95-0.99), p<0.05; full-fat dairy 0.96 (0.93-0.99), p<0.05; milk 0.92 (0.88-0.97), p<0.05. Higher intake of total dairy (>2 servings/d vs. none) was associated with a lower risk of CVD mortality (HR: 0.77; 95% CI: 0.58-1.01; p=0.029), major CVD events (HR: 0.78; 95% CI: 0.67-0.90; p=0.0001), and stroke (HR: 0.66; 95% CI: 0.53-0.82; p=0.0003). Higher consumption of milk and yoghurt, but not cheese, was associated with a lower risk of major CVD events or mortality.	IA
(6)	2020	NR	Dairy	Dairy foods may have protective effects on stroke, findings that were not confirmed by all meta-analyses. Yoghurt without sugar may have a beneficial effect. The EPIC Cohort with more than 400,000 participants led to unclear conclusions. After more than 12 years and over 7,000 myocardial infarctions, there was only a modest inverse association with cheese and yoghurt. This association disappeared when controlling for confounders.	IIB
Cancer					
(8)	2019	SR / MA	Dairy	A total of 15 cohort studies and 14 case-control studies with more than 22.000 cases were analysed. The cohort studies consistently showed a significant decrease in colorectal cancer (CRC) risk	I/IIA

Ref.	Year	Type	Food type	Results	Grade
				associated with higher consumption of total dairy products (RR: 0.80; 95% CI: 0.70-0.91) and total milk (RR: 0.82; 95% CI: 0.76-0.88) compared with the CRC risk associated with lower consumption. The cohorts also showed a significant protective association between low-fat milk consumption and CRC (RR: 0.76; 95% CI: 0.66-0.88), and for colon cancer only (RR: 0.73; 95% CI: 0.61-0.87). Cheese consumption was inversely associated with the risk of CRC (RR: 0.85; 95% CI: 0.76-0.96) and proximal colon cancer (RR: 0.74; 95% CI: 0.60-0.91). No significant associations with CRC were found for the consumption of low-fat dairy products, whole milk, fermented dairy products, or cultured milk. Most of these associations were not supported by the case-control studies.	
(13)	2019	SR / MA	Dairy	Medium quantities of milk and dairy consumptions were associated with a lower risk of bladder cancer for total dairy products (RR: 0.90; 95% CI: 0.81-0.98), milk (RR: 0.90; 95% CI: 0.82-0.98), and fermented dairy products (RR: 0.87; 95% CI: 0.79-0.96), compared with low consumption. High compared with low consumption was significantly associated with a lower risk for milk (RR: 0.89; 95% CI: 0.81-0.98) and fermented dairy products (RR: 0.78; 95% CI: 0.61-0.94). However, high whole milk consumption compared with low consumption was significantly associated with a higher bladder cancer risk (RR: 1.21; 95% CI: 1.04-1.38).	IIA
(9)	2020	MA	Dairy	Meta-analysis of 31 prospective cohort studies, which included 24.964 cases for colorectal cancer and 2.302 cases of mortality. The pooled RR of colorectal cancer incidence for the highest versus lowest categories of total dairy consumption was 0.79 (95% CI: 0.74-0.85). For milk consumption, there was also a significant inverse association (RR, 0.81; 95% CI, 0.76-0.86). For cheese and fermented milk consumption, overall no association was found, but studies from Europe showed a significant inverse association for cheese (RR, 0.87; 95% CI, 0.78-0.97) and fermented milk consumption (RR, 0.91; 95% CI, 0.85-0.98). For colorectal cancer mortality, a 29% lower risk of death from colorectal cancer in subjects with high dairy consumption compared with those with low intakes was found (RR, 0.71; 95% CI, 0.54-0.93), but no association was found for each type of dairy.	IA
(16)	2019	SR	Dairy	Two meta-analyses, 14 prospective cohorts, and 8 case-control studies assessed the association of total dairy intake and prostate cancer (PC) risk. Most prospective cohort studies demonstrated an association with either no change in risk or an increased risk of PC. These results were confirmed when only the larger cohort studies were considered. In addition, 3 meta-analyses showed an association between the intake of dairy products and an increased PC risk.	IIIA
(28)	2018	SR	Dairy	No strong evidence was found that high levels of dairy consumption are associated with an increased risk of testicular cancer (TC). There is conflicting evidence of a dose-response relationship for the development of TC and inconsistent evidence on whether certain types of dairy are stronger associated with TC risk than others. There is conflicting evidence that an exposure during certain life-course periods affects TC risk more than other periods of life.	IIC
(14)	2021	MA	Dairy	Dairy consumption was not associated with a higher risk of breast cancer (BC). Higher yoghurt (HR 0.85; 95% CI: 0.76-0.95)) and cottage/ricotta cheese (HR: 0.90; 95% CI: 0.83-0.98)) intakes were	IA

Ref.	Year	Type	Food type	Results	Grade
				inversely associated with the risk of ER-negative breast cancer (= less hormonally dependent subtype with poor prognosis).	
(15)	2019	MA	Dairy	The present meta-analysis involving 50,777 participants and 4,635 cases from 12 publications showed an inverse association between milk and dairy consumption and oral and oropharyngeal cancer risk (OR: 0.74; 95% CI: 0.59-0.92). Four studies on the effect of milk consumption on oral cancer risk found no significant association (OR: 0.91; 95% CI: 0.61-1.37). Six studies about milk consumption and oropharyngeal cancer risk found a negative association (OR: 0.63; 95% CI: 0.44-0.90).	IIA
(10)	2019	NR	Dairy	A meta-analysis concluded that dairy may be protective against colorectal cancer. There is strong evidence that a diet poor in dairy increases the risk for colorectal cancer (1.2x increased risk).	IA
(11)	2020	NR	Dairy	In one of the most representative studies, a high-fat content in the consumption of dairy products was observed in 60,708 women, aged between 40 and 76 years, with about 14 years of follow-up. It was found that women who consumed 4 or more portions of dairy products, including whole milk, cheese, cream cheese, sour cream, and butter, showed half of the risk of developing colorectal cancer compared with women who consumed less than a portion a day of these products.	IC
(12)	2020	NR	Dairy	The consumption of dairy products was strongly associated with prostate cancer, breast cancer, and other cancers. In prospective cohort studies, milk consumption was most consistently associated with an increased risk of prostate cancer, especially with aggressive or deadly forms. No associations were found with increased risks of breast cancer. Total dairy intake was associated with an increased risk of endometrial cancer, especially in post-menopausal women without hormone replacement therapy. Consumption of dairy products was believed to increase the risk of ovarian cancer, but no association was shown in pooled analyses. Milk consumption was inversely associated with the risk of colorectal cancer in meta-analyses and pooled analyses of primary data.	IIA
(17)	2020	NR	Dairy	Two cohort studies showed an association between higher total dairy intakes (three servings per day or more) with a statistically significant higher risk of hepato-cell carcinoma (HCC), while yoghurt consumption was associated with a lower HCC risk. Other cohorts did not confirm these results.	IIB
Diabetes					
(20)	2019	MA	Dairy, fermented dairy	Decreasing dairy intake by one or more servings per day over four years was associated with 11% (95% CI: 3-19%) higher risk of diabetes compared with no change in consumption in the subsequent four years. Increasing yoghurt consumption by half a serving per day was associated with 11% (95% CI: 4-18%) lower diabetes risk. Increasing cheese consumption by half a serving per day was associated with 9% (95% CI: 2-16%) higher risk compared with no change. Substituting cheese with one serving per day of reduced-fat milk or yoghurt was associated with 16% (95% CI: 10-22%) or 12% (95% CI: 8-16%) lower diabetes risk, respectively.	IIA
(19)	2019	MA	Dairy	Data from 16 prospective cohort studies and a total of 545,677 participants were analysed. Pooled results showed an inverse association between dairy consumption and the risk of diabetes (RR:	IA

Ref.	Year	Type	Food type	Results	Grade
				0.897; 95% CI: 0.834-0.963; p<0.01). Subgroup analysis showed that the association between dairy intake and diabetes is significant in women (RR: 0.868; 95% CI: 0.82-0.92; p<0.001) but not in men.	
(18)	2020	MA	Dairy	The meta-analysis showed a negative association between total dairy intake and risk of diabetes (RR 0.94; 95% CI: 0.89-1.00). The risk was lowest at 270 g dairy intake per day.	IA
(21)	2021	RCT	Milk	Baseline data from dietary intervention study (cross-sectional). The association between milk intake and fasting blood glucose levels in individuals with diabetes was significant (OR: 17.19), while it was not in nondiabetic individuals (OR: 2.31).	IIIC
(22)	2021	RCT	Kefir / Curd	Kefir consumption decreased fasting glucose levels significantly, although HbA1c remained unchanged. Curd did not induce any change in glycaemic parameters during the study.	IIB
(29)	2020	RCT	Dairy	In patients with type 2 diabetes, increased dairy consumption over 24 weeks to three or more servings per day, compared with less increase, irrespective of its fat content and while maintaining total energy intake, has no effect on HbA_1c.	IIB
(6)	2020	NR	Dairy, fermented dairy	Dairy foods may have protective effects on type 2 diabetes risk. However, these findings were not confirmed by all meta-analyses. Yoghurt without sugar may have a beneficial effect on the risk of type 2 diabetes. A meta-analysis concluded that the protective effect in diabetes patients derives from low-fat products, especially from yoghurt. The men’s Health Professionals Study and the Women’s Nurses Study showed that dairy foods reduced the risk of diabetes when they replaced carbohydrates, but not when they replaced whole grain products. Overall, the risk of diabetes was smaller for dairies compared to other animal foods. A recent systematic review and meta-analysis showed that yoghurt reduced the risk of diabetes by 27%. Yoghurt and cheese, which were associated the strongest with reduced type 2 diabetes, may reflect protective processes of fermentation that have not been fully elucidated yet. Milk, cheese and yoghurt should be separately classified from butter.	IA
(12)	2020	NR	Dairy, milk	The intake of dairies was associated with a modestly lower risk of diabetes in some cohort studies. However, in large meta-analyses, dairy consumption was not or only weakly associated with a lower risk. In a substitution trial, the risk of diabetes was lower with milk consumption than with sugar-sweetened beverages or fruit juices, but higher than with coffee. Moreover, total dairy intake has not been clearly related to diabetes risk.	IIA
(3)	2020	NR	Milk / yoghurt	The consumption of milk and yoghurt was associated with a substantially reduced risk of diabetes. The reduced diabetes risk associated with yoghurt consumption was also highlighted in a recent review. A dose-response meta-analysis of 11 cohorts showed a negative association with diabetes.	IA
Obesity / weight loss					
(30)	2018	RCT	High vs. low dairy intake	Participants in both groups (high dairy (HD) and low dairy (LD) groups) significantly lost weight from baseline to week 24, with no difference between them (p=0.73). Both groups significantly reduced hip circumference (HC) and waist circumference (WC), with a larger decrease in HC (p=0.003) and a tendency for a larger decrease in WC (p=0.074) in the LD group.	IIB

Ref.	Year	Type	Food type	Results	Grade
(22)	2021	RCT	Kefir vs. curd	Neither kefir nor curd intake over a period of 12 weeks induced alterations in any anthropometric parameters (BMI, lean mass, fat mass and waist circumference) in the study participants.	IIB
(3)	2020	NR	Dairy	A large amount of data from observational, cross-sectional, and prospective studies showed a negative association between dairy intake and body weight and central obesity. A review of observational and interventional studies found that high-fat dairy consumption was inversely associated with obesity in most studies. A meta-analysis of 29 RCTs showed that the inclusion of dairy foods in weight maintenance diets was not associated with weight loss or weight gain. However, an additional weight loss effect was shown if dairy foods were combined with energy-restricted diets.	IA
(23)	2019	RCT	Low-fat dairy vs. placebo	Increasing low-fat dairy foods to 4-5 servings per day during a moderate weight loss diet resulted in the strongest decrease in total body fat and the lowest decrease in lean mass compared to control groups, in postmenopausal obese women around the age of 55.	IB
(24)	2021	RCT	Milk vs. pistachio	In a randomized cross-over trial on milk vs pistachio intake, sixty overweight and obese women with a mean age of 24.42 ± 4.2 years participated. Each Intervention lasted two periods of one month each. Body fat percentage in women in the milk group significantly decreased compared to the control group (p=0.001).	IB
(25)	2020	Overview of 6 SR + 47 MA	Dairy	In adults, increasing total dairy intake without energy restriction does not seem to affect body composition. However, in the context of an energy-restricted diet increased dairy intake can lead to lower fat mass and body weight. No conclusive effects on waist circumference or lean mass.	IIA
(29)	2020	RCT	Low-fat vs. no-fat dairy	In patients with type 2 diabetes, increased dairy consumption to three or more servings per day for 24 weeks and while maintaining energy intake, compared with less dairy intake per day and irrespective of its fat content, has no effect on body weight and body composition.	IIB
(31)	2021	RCT	Dairy (low-fat, full-fat, limited dairy)	In this ad libitum study, body weight changed differentially (p=0.006 overall), increasing with full-fat dairy (+1.0 kg; 95% CI: −0.2-1.8) compared to the limited dairy diet (−0.4 kg; 95% CI: −2.5-0.7). The low-fat dairy diet (+0.3 kg; 95% CI: −1.1-1.9) was not significantly different from the other two interventions. An overall intervention effect was seen for waist circumference (overall time × intervention interaction p=0.015), with a significant increase in waist circumference in both dairy groups compared with the limited dairy group.	IIB
(26)	2019	SR / MA of RCTs	Dairy	Meta-analysis of 30 RCTs: For waist circumference (1,348 individuals), the mean difference was −1.09 cm (95% CI: 1.68 to −0.58; p<0.00001). For body weight (2,362 individuals), the dairy intake intervention group lost 0.42 kg more than the control group (p<0.00001).	IA
(12)	2020	NR	Dairy	Overall, the results of prospective cohort studies and randomized controlled trials do not show a clear impact of milk consumption on body weight. There is no evidence to support the advice to choose fat-reduced dairy and low-fat milk does not seem to have advantages over whole milk for weight reduction. Regular consumption of yoghurt may lead to less weight gain. However, this association needs further investigation in randomized controlled trials to exclude confounding.	IIA

Ref.	Year	Type	Food type	Results	Grade
(27)	2021	RCT	Goat milk vs. no treatment	RCT of 110 days with 18 participants. Significant decrease of weight (before: 51.22 kg, after: 48.83 kg; p=0.001) and BMI (before: 21.18 kg/m^2, after: 20.02 kg/m^2; p=0.001) after daily goat milk consumption in the intervention group. In the control group, there were no difference in weight (before: 53.72 kg, after: 53.05 kg; p=0.066) and BMI (before: 22.04 vs. 22.07 kg/m^2; p=0.068).	IB

MA: meta-analysis; NR: narrative review; RCT: randomized controlled trial; SR, systematic review.

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2.9 Legumes, pulses and soy

Author: Sabine Rohrmann Reviewer: Beatrice Baumer

2.9.1 Introduction

Legumes are defined in the Swiss Ordinance [817.022.109]. This group belongs to the *Fabaceae* family and encompasses beans, lentils, peas, chickpeas, soybeans, and peanuts, but also alfalfa, clover, and lupin beans. The term "pulses" refers to crops harvested for the dry seed, whereas the unripe seeds and pods, e.g., green peas and green beans, are considered vegetables. Legumes are rich in protein, dietary fibre, and carbohydrates ("resistant starch" and oligosaccharides), and they are also important sources of certain minerals (e.g., iron, zinc, and potassium) and vitamins, namely B-vitamins such as folate (1).

Legumes are abundant in the essential amino acids lysine and threonine, which are typically low in other plant-based protein sources, but low in other amino acids, including methionine, tryptophan, and cysteine (with the exception of soy and soy products; see (2, 3). Because of the latter, legumes are often considered to be of lower protein quality. However, if consumed in conjunction with complementary plant-based and/or animal protein sources that contain the limiting essential amino acids they form a diet containing a high-quality protein mixture.

Soy and soy products are traditionally consumed in many Asian countries but are increasingly used and consumed in Western societies. Often, soy products in Western societies are consumed not only because of their protein content, but also as a replacement for milk and dairy in vegan/vegetarian/ flexitarian diets, as well as alternatives for individuals with milk allergies or lactose intolerance.

2.9.2 Search strategy

A systematic search was conducted to find publications. The syntax is provided in the annex, chapter 2.9. If no relevant literature was found by the systematic search, a "free" search in PubMed was conducted. This "free" search provided the umbrella review by Li et al. on soy consumption and health outcomes (4), which was not found by the systematic search. The review of the results on soy consumption are based on this umbrella review. More recent systematic reviews and meta-analyses or those that were not included in the umbrella review were used additionally. Also, an umbrella review by Papadimitriou et al. on diet and cancer risk (5) was not found by the systematic search. This umbrella review, however, was based on the results of the Third Report, the World Cancer Research Fund / American Association for Cancer Research (WCRF/AICR) that conducts rigorous and exhaustive systematic review of the association between diet and cancer risk (6). Therefore, the UR was not considered in this evaluation. Thirdly, the UR and SR/MA by Viguiliouk et al. (7) was not picked up by the search strategy.

Products made from legumes such as pea protein, are not considered in this review as this is a rather recent development on the food market and studies on their health effects have not been conducted (or published) yet.

2.9.3 Main findings

An umbrella review published in 2019 reviewed the association of the consumption of soy and soy products and a number of health outcomes. As shown in **Table 27** the studies included in the single meta-analyses were case-control and cohort studies, but no RCT were available (besides body weight). For most health outcomes, inverse associations between soy/soy product consumption and diseases were observed, the evidence of these studies was graded as very low, low, or moderate. Evidence was considered as moderate for gastric cancer (soy; non-fermented soy products; miso soup) and body weight. The evidence for T2D was different in the three meta-analyses (see **Tables 27 and 28**) depending on the number and type of studies included.

Less evidence is available for the consumption of other **pulses**. An umbrella review conducted in 2019 concluded that high consumption of dietary pulses with or without other legumes (i.e., "legumes" without differentiating the legume type or including other types of legumes in the exposure in addition to pulses [e.g., soybeans, soy products, peanuts, fresh peas, and/or fresh beans]) is associated with reduced

CVD incidence and reduced CHD, hypertension, and obesity incidence (7)**.** Two studies were found that have been published after this UR (**Table 29**). Both examined the association with T2D and provided mixed results, such that the consumption of legumes or pulses with not associated with the risk of T2D or with an increased risk. WCRF/AICR examined the effects of the consumption of pulses on cancer risk and concluded that data were either of too low quality or too inconsistent, or the number of studies too few, to allow conclusion to be reached (6).

2.9.4 Conclusion

2.9.4.1 Conclusion of the previous report

The 2019 FCN report (reference) concluded that legumes should be given more weight in the pyramid. The positioning of legumes in starchy foods was seen as very questionable also due to their main ingredients. It was recommended that pulses (ripe dry seed) should be a component of protein-rich foods in the Swiss food pyramid, instead of only tofu. Furthermore, pulses and then possible pulse-derived products such as tofu, tempeh, etc. should be listed. Unripe legumes such as green peas and green beans should be clearly listed in the food group “fruit and vegetables”.

2.9.4.2 Conclusion of the current report

Higher consumption of soy was associated with a decreased risk of some types of CVD, some types of cancer, and T2D, but there does not appear to be an association with body weight. The level of evidence is considered very low to low, given that fact the not RCTs are available (except for body weight).

The higher consumption of other legumes (pulses) was inversely associated with some CVD outcomes and obesity, but there were not associations with cancer types (but studies are rare). The most recent SR/MA indicated a possible positive association between total legume consumption and T2D, but heterogeneity between studies is high.

Due to the heterogeneity between studies, it was difficult to determine a minimal, optimal, or maximal consumption of soy products with respect to CVD and cancer.

The conclusions of the 2019 FCN report can be maintained.

Table 25: Summary legumes, pulses and soy and NCD

Conclusion	**Class**	**Level**
Soy		
Increasing soy consumption decreases the risk of CVD	I/II**	B
Increasing soy consumption decreases the risk of cancer	I/II*	B
Increasing soy consumption might decrease the risk of T2D	II	B
Increasing soy consumption might decrease the risk of obesity	II	B
Pulses		
Increasing pulses consumption decreases the risk of CVD	I/II**	B
Increasing pulses consumption might decrease the risk of cancer	II	B
Increasing pulses consumption might decrease the risk of T2D	II/III	B
Increasing pulses consumption decreases the risk of obesity	I***	B

* depends on cancer types; ** depends on CVD outcome; ***one study only.

2.9.5 Recommendations

Table 26: Estimation of minimum, optimal, and maximum amount for consumption of legumes, pulses and soy in relation to NCD

Food group / NCD	Minimum	Maximum	Optimal
Soy			
CVD	-	-	-
Cancer	-	-	-
T2D	-	-	-
Obesity	-	-	-
Pulses			
CVD	1 serving/day	1 serving/day	1 serving/day
Cancer	-	-	-
T2D	-	-	-
Obesity	-	-	-

-, not reported

Table 27: Umbrella review for soy consumption and health outcomes (4)

Outcome	Category	No. of cases / total	MA metric	Estimates	95% CI	N studies in MA	PCS	CCS	RCT
Cardiovascular disease									
Mortality									
N. Namazi, et al. *Food Funct.* 2018, 9, 2576.	Soy	6028 / 140,893	RR[d]	0.95	0.82-1.10	4	4	0	0
N. Namazi, et al., *Food Funct.* 2018, 9, 2576.	Fermented soy products	1910 / 69,529	RR[c]	0.84	0.73-0.97	3	3	0	0
CVD									
Z. Yan, et al. *Eur. J. Prevent. Cardiol.* 2017, 24, 735.	Soy	17,269 / 492,676	RR[d]	0.83	0.75-0.93	17	10	7	0
Stroke									
Z. Yan, et al., *Eur. J. Prevent. Cardiol.* 2017, 24, 735.	Soy	6265 / 373,928	RR[d]	0.82	0.68-0.99	11	7	4	0
CHD									
Z. Yan, et al. *Eur. J. Prevent. Cardiol.* 2017, 24, 735.	Soy	10,806 / 441,140	RR[d]	0.83	0.72-0.95	12	8	4	0
Cancer									
Mortality									
N. Namazi, et al. *Food Funct.* 2018, 9, 2576.	Soy	12,802 / 144,490	RR[d]	0.98	0.92-1.05	4	4	0	0
Breast cancer									
T. T. Zhao, et al., *Clin. Nutr.* 2019, 38, 136.	Soy	8041 / 409,970	RR[a]	0.87	0.76-1.00	6	6	0	0

Outcome	Category	No. of cases / total	MA metric	Estimates	95% CI	N studies in MA	PCS	CCS	RCT
Ovarian cancer									
S. K. Myung et al. *BJOG* 2009, 116, 1697.	Soy	1912 / 163,879	OR[a]	0.52	0.42-0.66	4	2	2	0
Prostate cancer									
C. C. Applegate et al. *Nutrients* 2018, 10, 40.	Soy	21,612 / 266,699	RR[b]	0.71	0.58-0.85	30	8	22	0
Gastric cancer									
K. G. Weng, Y. L. Yuan, *Medicine* 2017, 96, e7802.	Soy	5800 / 517,106	RR[a]	0.78	0.62-0.98	7	7	0	0
K. G. Weng, Y. L. Yuan, *Medicine* 2017, 96, e7802.	Non-fermented soy products	1022 / 80,573	RR[a]	0.63	0.50-0.79	4	4	0	0
K. G. Weng, Y. L. Yuan, *Medicine* 2017, 96, e7802.	Miso soup	1484 / 72,083	RR[a]	1.17	1.02-1.36	4	4	0	0
Colorectal cancer									
Y. Yu, et al. *Sci. Rep.* 2016, 6, 25939.	Soy	7659 / 266,895	RR[a]	0.79	0.69-0.89	14	4	10	0
Lung cancer									
S. H. Wu, Z. Liu, *Nutr. Cancer* 2013, 65, 625.	Soy	6811 / 231,494	OR[a]	0.83	0.72-0.96	11	4	7	0
Diabetes									
W. Li, et al. Diabetes Res. Clin. Pract. 2018, 137, 190.	Soy	7589 / 335,230*	RR[d]	0.77	0.66-0.91	19	14	5[#]	0

Outcome	Category	No. of cases / total	MA metric	Estimates	95% CI	N studies in MA	PCS	CCS	RCT
Obesity									
M. Akhlaghi, et al. Adv. Nutr. 2017, 8, 705.	Soy	325 / 325	MD[b]	0.8	0.15-1.45	8	0	0	8

[a] highest versus lowest/none; [b] any versus none; [c] unclear from publication; [d] highest versus lowest/none; [#] cross-sectional.

CCS, case-control study; PCS, prospective cohort study; RCT, randomized controlled trial.

Table 30 (continued). Umbrella review for soy consumption and health outcomes (4)

Outcome	**Category**	**I^2 [%]**	**Egger test *p*-value**	**AMSTAR**	**GRADE**
CVD					
Mortality					
N. Namazi, et al. *Food Funct.* 2018, 9, 2576.	Soy	49.9	0.4	9	Low
N. Namazi, et al., *Food Funct.* 2018, 9, 2576.	Fermented soy products	0	NA	9	Low
CVD					
Z. Yan, et al. *Eur. J. Prevent. Cardiol.* 2017, 24, 735.	Soy	71.4	0.02	8.5	Very low
Stroke					
Z. Yan, et al., *Eur. J. Prevent. Cardiol.* 2017, 24, 735.	Soy	78.8	0.01	8.5	Very low
CHD					
Z. Yan, et al. *Eur. J. Prevent. Cardiol.* 2017, 24, 735.	Soy	64.6	0.3	8.5	Very low
Cancer					
Mortality					
N. Namazi, et al. *Food Funct.* 2018, 9, 2576.	Soy	0	0.46	9	Low
Breast cancer					
T. T. Zhao, et al., *Clin. Nutr.* 2019, 38, 136.	Soy	0	NA	9	Low
Ovarian cancer					
S. K. Myung et al. *BJOG* 2009, 116, 1697.	Soy	0	NA	8.5	Low
Prostate cancer					
C. C. Applegate et al. *Nutrients* 2018, 10, 40.	Soy	68.9	0.05	9.5	Very low
Gastric cancer					

Outcome	**Category**	***I*²** **[%]**	**Egger test *p*-value**	**AMSTAR**	**GRADE**
K. G. Weng, Y. L. Yuan, *Medicine* 2017, 96, e7802.	Soy	47.5	0.11	9.5	Moderate
K. G. Weng, Y. L. Yuan, *Medicine* 2017, 96, e7802.	Non-fermented soy products	0	0.72	9.5	Moderate
K. G. Weng, Y. L. Yuan, *Medicine* 2017, 96, e7802.	Miso soup	0	0.18	9.5	Moderate
Colorectal cancer					
Y. Yu, et al. *Sci. Rep.* 2016, 6, 25939.	Soy	46.2	NA	6	Low
Lung cancer					
S. H. Wu, Z. Liu, *Nutr. Cancer* 2013, 65, 625.	Soy	NA	0.1	6	Very low
Diabetes					
W. Li, et al. Diabetes Res. Clin. Pract. 2018, 137, 190.	Soy	91.6	0.03	9	Very low
Obesity					
M. Akhlaghi, et al. Adv. Nutr. 2017, 8, 705.	Soy	38.7	NA	7.5	Moderate

Table 28: Results of the associations between soy/soy product intake and health outcomes

Ref	Year	Type	Food type	Results	Grade
Cardiovascular disease					
(8)	2019	SR	Soy and soy products	Soy/soy products consumption was inversely associated with deaths from CVD (pooled effect size: 0.85; 95% CI: 0.72-0.99; p=0.04; I^2=50.0%, n=8).	IB
Cancer					
(8)	2019	SR	Soy and soy products	Soy/soy products consumption was inversely associated with deaths from cancers (pooled relative risk 0.88; 95% CI: 0.79-0.99; p=0.03; I^2=47.1%, n=9).	IB
Hepatocellular cancer					
(9)	2021	SR (no MA)	Soy	Increased intake of soy foods was found to reduce risk of HCC in a cohort-based, nested case-control study conducted within the Japanese population *(10)*. Intake of miso soup (>17.1 g/day) or tofu (>76.3 g/day) more than 5 times/week was associated with 50% lower HCC risk, when compared to less than once a week. This reduction in crude HCC risk was 0.89 for miso soup and 0.92 for tofu, per additional serving.	IIB
Breast cancer					
(11)	2018	SR/MA	Soy or isoflavone (mixed)	Consumption of soy or isoflavones was inversely associated with overall survival [(RR: 0.84; 95% CI: 0.71-0.98); n=10 studies] Consumption of soy or isoflavones was not statistically significantly associated with breast cancer specific survival [(RR: 0.89; 95% CI: 0.74-1.07); n=6 studies]	IB IIB
Diabetes					
(12)	2020	SR/MA	Soy	The summary RRs (95% CIs) of incident T2D were 0.83 (0.68-1.01) for total soy, 0.89 (0.71, 1.11) for soy milk, 0.92 (0.84-0.99) for tofu, and 0.84 (0.75-0.95) for soy protein, respectively. In dose-response analysis, significant linear inverse associations were observed for tofu, and soy protein (all $p < 0.05$). Overall quality of evidence was rated as low for total soy and soy subtypes.	I/IIB

Ref	Year	Type	Food type	Results	Grade
(13)	2021	Federated MA §	Soy	No evidence of a statistically significant association was observed for the consumption of soy (10 PCS: RR: 1.02; 95% CI: 0.99-1.01 per 20 g/day). Heterogeneity between regions.	IIB

MA: Meta-analysis; PCS, prospective cohort study; RCT: randomized controlled trial; SR, systematic review; UR, umbrella review. Only studies published after the umbrella review has been published are indicated. §, also unpublished results.

Table 29: Results of the associations between consumption of legumes/pulses and health outcomes

Ref.	Year	Type	Food type	Results	Grade
Cardiovascular disease					
(7)	2019	UR; SR and MA	Pulses / legumes	Six SR-MAs were identified and updated to include 28 unique prospective cohort studies. Comparing the highest with the lowest level of intake, dietary pulses with or without other legumes* were associated with significant decreases in CVD (RR: 0.92; 95% CI: 0.85-0.99) and CHD (RR: 0.90; 95% CI: 0.83-0.99). There was no association with MI, stroke, or CVD, CHD, and stroke mortality. The overall certainty of the evidence was graded as "low" for CVD incidence and "very low" for all other outcomes.	IB IIB
Cancer					
(6)	2018	SR/MA	Pulses	Data were either of too low quality or too inconsistent, or the number of studies too few, to allow conclusion to be reached.	IIB
Diabetes					
(7)	2019	UR; SR and MA	Pulses / legumes	Six SRMAs were identified and updated to include 28 unique prospective cohort studies. There was no association with T2D incidence. The overall certainty of the evidence was graded as "very low".	IIB
(12)	2020	SR/MA	Legume	The summary RRs (95% CIs) of incident T2D were 0.95 (0.79-1.14) for total legumes. Overall quality of evidence was rated as moderate for total legumes.	IIB
(13)	2021	Federated MA §	Total pulses / legumes	Weak positive association between total legume consumption and T2D (incidence rate ratio [IRR]: 1.02; 95% CI: 1.01-1.04; 21 cohort studies) per 20 g/day higher intake, with moderately high heterogeneity (15 studies; I^2=74%). No evidence of associations was observed for the consumption of pulses [*i.e., legumes besides soy*] (IRR: 1.02; 1.00-1.03; 13 cohort studies)	II/IIIB
Obesity					
(7)	2019	UR; SR and MA	Pulses / legumes	Six SR-MAs were identified and updated to include 28 unique prospective cohort studies. Comparing the highest with the lowest level of intake, dietary pulses with or without other legumes*	IB

Ref.	Year	Type	Food type	Results	Grade
				were associated with significant decreases in obesity (RR: 0.87; 95% CI: 0.81-0.94) incidence. The overall certainty of the evidence was graded as "very low".	

MA: Meta-analysis; PCS, prospective cohort study; RCT: randomized controlled trial; SR, systematic review; UR, umbrella review. §, also unpublished results.

*"Pulses" reporting only chickpeas, lentils, beans, and/or peas in the exposure. "Pulses + other legumes" reporting "legumes" without differentiating the legume type or including other types of legumes in the exposure in addition to pulses (e.g., soybeans, soy products, peanuts, fresh peas, and/or fresh beans)

2.9.6 References

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2.10 Plant protein

Author: Sabine Rohrmann Reviewer: Beatrice Baumer

2.10.1 Introduction

There is a growing demand for dietary protein worldwide (1). Protein from meat, poultry, fish, dairy and eggs have good amino acid composition and high digestibility, whereas plant protein (i.e., protein from non-animal sources) in general has a lower concentration of some essential amino acids. However, the combination of different food groups increases the protein quality. For example, the combination of cereal products with legumes, milk with potatoes, or egg with cereal products leads to a good protein quality. Beyond the nutritional aspects of proteins, the role of high-quality dietary protein needs to be investigated also in a broader context, in particular environmental concerns and increasing protein demand (2).

2.10.2 Search strategy

A systematic search was conducted to find publications. The syntax is provided in the annex, chapter 2.10. If no relevant literature was found by the systematic search, a “free” search in PubMed was conducted. No SRs/MAs on plant protein consumption (or related terms) and body weight were found, but a free search provided results of a cross-sectional study and a SR of RCTs.

2.10.3 Main findings

Since the publication of the EEK report, several studies and systematic reviews have been published on consumption of plant proteins and CVD risk and mortality, cancer mortality, and risk of T2D. Although some studies observed statistically significant inverse associations between consumption of plant proteins and some diseases outcomes (see **Table 32**), most of studies did not find any statistically significant associations. Although generally inverse, the associations with CVD mortality tend to be rather weak. An SR of RCTs did not provide evidence of a prospective effect when compared with an animal protein (3).

2.10.4 Conclusion

2.10.4.1 Conclusion of the previous report

Plant proteins have been examined in the previous report (4), but no firm conclusions were drawn due to the lack of data, as indicated:

“Plant-protein based products, in particular some ready-to-cook meat analogues, which are sometimes rich in salt and saturated fatty acids, are highly processed […]; this type of products has not yet been sufficiently investigated, currently there is no evidence which supports their recommendation.

Furthermore, "quorn", which is a trade name for a specific commercial product, should not be mentioned in the recommendations, especially as there are no specific studies on this subject and many similar products are currently being sold.” (4).

2.10.4.2 Conclusion of the current report

There is no consistent evidence that higher consumption of plant proteins is significantly associated with a decreased risk of CVD, cancer, T2D or obesity. For CVD, associations with CVD mortality were generally inverse, but there was no statistically significant inverse association with incident CVD.

Table 30: Summary plant protein intake and risk of NCD

Conclusion	Class	Level
Increasing consumption of plant protein might decrease the risk of CVD	II	A
Increasing consumption of plant protein might decrease the risk of cancer	II	A
Increasing consumption of plant protein might decrease the risk of T2D	II	A
Increasing consumption of plant protein might decrease the risk of obesity	II	A

2.10.5 Recommendations

Table 31: Estimation of minimum, optimal, and maximum amount of plant protein intake in relation to NCD

Food group	**NCD**	**Minimum**	**Maximum**	**Optimal**
Plant protein	CVD	-	-	-
Plant protein	Cancer	-	-	-
Plant protein	T2D	-	-	-
Plant protein	Obesity	-	-	-

-, not reported.

Table 32: Results of the associations between consumption of plant proteins and health outcomes

Ref	Year	Type	Food type	Results	Grade
Cardiovascular disease					
(5)	2020	MA (PCS)	Plant protein	A higher plant protein intake was associated with lower CVD mortality (highest versus lowest, RR: 0.86; 95% CI: 0.73-1.00; n=6)	IIA
(6)	2020	SR/ dose-response MA (PCS)	Plant protein	Intake of plant protein was significantly associated with a lower risk of CVD mortality (pooled HR: 0.88; 95% CI: 0.80-0.96, I^2=63.7%, n=12)	IA
(7)	2020	SR/MA	Plant protein	Higher plant protein intake may be associated with a reduced risk of CVD mortality (highest vs. lowest intake: RR: 0.90; 95% CI: 0.80-1.01; each 3% increment of intake: RR: 0.95; 95% CI: 0.91-0.99; n=7)	IIA
(8)	2020	SR/ dose-response MA (PCS)	Plant protein	Consumption of dietary plant protein was not related to the risk of total CHD (HR: 0.8; 95% CI: 0.74-1.01; n=5).	IIA
Cancer					
(5)	2020	MA (PCS)	Plant protein	A higher plant protein intake was not significantly associated with cancer mortality (HR: 0.97; 95% CI: 0.90-1.04; n=5).	IIA
(6)	2020	SR/ dose-response MA (PCS)	Plant protein	Intake of plant protein was not associated with cancer mortality (HR: 0.99; 95% CI: 0.94-1.05; n=10).	IIA
(7)	2020	SR/MA	Plant protein	Higher plant protein intake was not associated with cancer mortality (HR: 0.96; 95% CI: 0.88-1.04; n=6).	IIA
Diabetes					
(9)	2019	Dose-response MA	Plant protein	High intake of plant protein did not affect T2D risk (RR: 0.93; 95% CI: 0.86, 1.01), whereas moderate intake was associated with a reduced risk of T2D (RR: 0.94; 95% CI: 0.92-0.97).	IIA
(10)	2019	UR	Plant protein	Plant protein intake was not associated with T2D risk (RR: 0.87; 95% CI: 0.74-1.01); evidence was considered low	IIA
Obesity					
(3)	2020	SR of RCTs	Different types of plant proteins	5 studies provided data on body weight at baseline and at the end of intervention. 4 studies used milk protein as a comparator, 1 used egg-white protein. Apart from an increase in waist circumference (in milk protein group vs. lupin group) in 1 study, none of the studies detected significant differences between the interventions	IIA

MA: Meta-analysis; PCS, prospective cohort study; RCT, randomized clinical trial; SR, systematic review; UR, umbrella review.

2.10.6 References

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2.11 Ultra-processed foods

Authors: Undine Lehmann. Reviewers: Nicole Bender

2.11.1 Introduction

The Federal Food Safety and Veterinary Office (FSVO) requested an update on high fat foods. We agreed within the consortium and in consultation with the FSVO that the review of high fat foods should be focused on the topic of ultra-processed foods, an emerging food group with substantial research activity in recent years and high importance for the Swiss population.

The concept of UPF was first proposed by a Brazilian team of Professor Carlos Monteiro (1). Monteiro defines the following: 'The term "ultra-processed" was coined to refer to industrial formulations manufactured from substances derived from foods or synthesized from other organic sources. They typically contain little or no whole foods, are ready-to-consume or heat up, and are fatty, salty or sugary and depleted in dietary fibre, protein, various micronutrients and other bioactive compounds. Examples include: sweet, fatty or salty packaged snack products, ice cream, sugar-sweetened beverages, chocolates, and confectionery, French fries, burgers and hot dogs, and poultry and fish nuggets.'… (2). To classify foods, the NOVA system was developed that bases classification on the nature, extent, and purpose of food processing. It contains currently four groups: 1) unprocessed or minimally processed foods; 2) processed culinary ingredients; 3) processed foods and 4) ultra-processed foods (2). With this approach, the NOVA system differs fundamentally from previous food classifications that always considered the nutritional value i.e., the content of nutrients to encourage and to limit.

In the last years, an increasing number of studies investigated the association between risk factors for NCD and disease endpoints and the consumption of UPF (see **Table 38**).

However, the NOVA is not the only attempt to classify foods according to processing. The EPIC has also developed definitions of processed foods, with three categories: highly processed foods, moderately processed foods, and non-processed foods but additionally, for each food category separately (e.g. cereals and cereal products) (3). Several additional classifications exist taking processing aspects into account (4). Thus, the definition of UPF is inconsistent in the scientific community nor without critics, particular due to questionable food categorization, the underlying concept and the rejection of reformulation as way to improve the nutritional quality of processed foods (4-6). While NOVA focusses on categorization according to processing, studies using NOVA do not explore this aspect of technological data but the nutritional data (5).

Within the EPIC study it was found that highly processed foods contributed to the intake of 50-90% of energy and most nutrients in Nordic and central European countries (3). In Switzerland, when classified with NOVA, 26% of energy intake came from UPF (7).

The Swiss Food Pyramid does not mention UPF specifically (8). The top level sweet, salty and alcoholic foods or beverages includes UPF but so can the other levels (e.g., chicken nuggets and fruit yoghurt in the milk, meat and fish category, packaged bread in the cereal category). It has to be noted that UPF can include a wide variety of foods from snacks to mixed main meals and beverages.

2.11.2 Search strategy

We searched the databases PubMed and EMBASE to identify publications about NCD (cancer, CVD, T2D and obesity) and the food group ultra-processed food ("ultraprocessed food*" OR "ultra-processed food*" OR "packaged food*" OR "convenience food*" OR "industrialized food*" OR highly processed food). To identify relevant results, we set the following filters: humans, English, 2015 onwards, reviews, systematic reviews, meta-analysis and RCTs. We were able to identify 31 results for the title and abstract screening, which we imported to systematic Review Tool "Rayyaan". In the following full-text screening, we excluded 26 studies for meeting the exclusion criteria such as "wrong scope", "wrong outcome", "wrong food item" or "wrong population". At the end of this process, we found five eligible studies, which were used for this review. In addition, we included a Swiss cross-sectional study as relevant for the local context in the analysis. The syntax is provided in the annex, chapter 2.11.

2.11.3 *Main findings*

Three reviews, one review and meta-analysis and a cross-sectional study from Switzerland were included in the review. The most recent and most comprehensive review and meta-analysis on UPF and NCD included forty-three observational studies (9). As this review included also the most relevant data from a narrative review of (10) and went beyond, the narrative review was not included in **Table 35**. Studies used mainly the NOVA classification.

2.11.3.1 Cardiovascular disease

Both included reviews (9, 10) that investigated the association between UPF intake and cardiovascular diseases based their evaluation on the French NutriNet-Santé study (11). The highest quartile UPF intakes (22% of weight in g/d) compared to the lowest were associated with a statistically significant increase in the rates of overall cardiovascular, coronary heart, and cerebrovascular disease by 12%, 13% and 11%, respectively. In contrast, in an US-American study, consumption of UPF in the highest quartile was associated with a 31% higher risk of all-cause mortality but not with CVD mortality (12).

There are several studies on risk factors for CVD (13) associated with UPF intake: one article (14) evaluated arterial hypertension as the main outcome, and it was observed that higher consumption of UPF (3^{rd} tertile of consumption vs. 1^{st} tertile) increased its incidence (HR: 1.21; 95% CI 1.06-1.37).

2.11.3.2 Cancer

The NutriNet-Santé study concluded that higher consumption of UPF was associated with a 12% increased risk of total cancer and 11% increased risk of breast cancer but not with prostate cancer (14). One case-control study found that regular UPF consumption was associated with increased breast cancer risk (adjusted OR: 2.35, 95% CI: 1.08-5.12) (15). Another case-control study found no significant associations between higher vs. lower consumption of UPF (33% vs. 18% of calories) and prostate cancer (OR: 0.92; 95% CI: 0.72-1.17) (16).

2.11.3.3 Diabetes

The association between UPF consumption and T2D was only investigated in the NutriNet-Santé study (17). Higher consumption of UPF was associated with a higher risk of T2D (HR for 10% increase in proportion of UPF: 1.15; 95% CI: 1.06-1.25) (17).

2.11.3.4 Obesity

Most studies that investigated the association between consumption of UPF and disease risk addressed the topic of obesity or overweight (9). In adults, 14 studies were included in this review. The meta-analysis demonstrated that consumption of UPF was associated with increased risk of overweight (OR: 1.36; 95% CI: 1.23-1.51; p<0.001), obesity (OR: 1.51; 95% CI: 1.34-1.70; p<0.001), and abdominal obesity (OR: 1.49; 95% CI: 1.34-1.66; p<0.0001).

Data from the cross-sectional Swiss National Nutrition Survey menuCH found that women in the highest quintile of UPF weight proportion had significantly higher odds of having obesity (OR: 3.01, 95% CI: 1.48-6.11), abdominal obesity (OR: 2.69, 95% CI: 1.43-5.05), and being in the highest category of the BMI - waist circumference composite outcome (OR: 3.28, 95% CI: 1.59-6.77). No relevant associations were observed in men (7).

One RCT investigated BMI changes related to a 2 weeks diet rich in UPF compared to unprocessed foods (18). Participants gained 0.9±0.3 kg (p=0.009) during the UPF diet and lost 0.9±0.3 kg (p=0.007) during the unprocessed diet.

2.11.4 *Limitations of the studies*

It has to be noted that the consumption of UPFs was classified very differently in studies (e.g. in percentage of energy, in percentage of weight) and comparison of high vs. low consumption differed markedly (e.g. lowest vs. highest quartile or quintile, <5 times per week vs. >5 times per week) which makes comparison difficult. Furthermore, some studies included quartiles and quintiles with overlapping below and above sample-based cut-off ranges for categories of lowest vs. highest consumption (e.g.,

≤36.5% of total calories was categorized as the lowest cut-off in one study, whereas >29% was the highest in another). These discrepancies limit comparability and conclusions about the amount of UPF in the diet that causes detrimental effects on health.

Some reviews included studies that used household availability of UPF (10) while other excluded these studies and used only studies indicating consumption data of UPF (e.g., by FFQ or 24h recall data) (9). Adjustment for confounding factors was partially not reported or differed between the studies e.g., adjustment for total energy intake or physical activity level were not always done and therefore, made comparison between studies difficult (10, 19).

Furthermore, no conclusion can be drawn about effects of different UPF on health depending on the food group, i.e. whether UPF mixed meals or UPF snacks are more detrimental to health than UPF in other food groups. Most studies did not differentiate UPF further and used the NOVA classification that is little differentiating.

None of the studies linking UPF to health outcomes does investigate effects of the manufacturing process on its own on health.

2.11.5 Mechanisms

Several emerging mechanisms are suggested to explain the effects of UPF on health, in particular in studies where differences in nutrient values are controlled for. Among others, the following mechanisms are discussed: 1) the nutritional quality of foods, 2) effects of processing on the food matrix resulting in altered bioavailability, digestion kinetics and glycaemic, satiety, antioxidant or alkalinizing potential, 3) effects on the gut microbiota e.g. by emulsifiers (20), 4) additional constituents of UPF such as carcinogenic compounds (e.g. acrylamide) or compounds which impact endocrine signalling and adversely affecting hormonally regulated metabolic processes (bisphenol A) (9, 10). Strong evidence or understanding of causal mechanisms is lacking.

2.11.6 Conclusion

There is moderate evidence that the consumption of UPF in high amounts is associated with an increased risk of CVD, increased risk of total and breast cancer and T2D. There is high evidence that the consumption of UPF in high amounts is associated with an increased risk of overweight and obesity. There is insufficient evidence to estimate the amount of UPF that results in these effects. However, already 22% of weight in the diet, vs. 11% per day exhibited clear negative effects in a big national cohort study; an amount that is also likely to be consumed in Switzerland.

Due to suggested detrimental effects on health of some additives used in UPF, consumers should be encouraged to choose products with a short ingredient list and recognizable ingredients, based on the so-called “kitchen-cupboard” or clean-label approach. More studies are needed to better understand the specific effects of UPF on health.

Table 33: Summary ultra-processed food intake and risk of NCD

Conclusion	**Class**	**Level**
UPF intake increases the risk of CVD	III	B
UPF intake increases the risk of certain cancers	III	B
UPF intake increases the risk of diabetes	III	B
UPF intake increases the risk of obesity	III	A

2.11.7 Recommendations

Based on the available evidence, the recommendation to limit the consumption of UPF can be made.

Further studies are required to better identify the mechanisms causing the detrimental health effects and to better differentiate the huge group of UPF and their effects on health.

Table 34: Estimation of minimum, optimal, and maximum amount of ultra-processed foods intake in relation to NCD

Food group	NCD	Minimum	Maximum	Optimal
UPF	CVD	0	-	0
UPF	Cancer	0	-	0
UPF	T2D	0	-	0
UPF	Obesity	0	-	0

-, not defined. Substantiated maximum amounts cannot be extracted from the studies but the optimal amount is as low as possible.

Table 35: Results of the associations between ultra-processed foods and health outcomes

Ref.	Year	Study	Food Type	Results	Grade
Cardiovascular disease					
(9)	2021	SR / MA	UPF	The prospective cohort study NutriNet-Santé (N=105,159) found that higher consumption of UPF vs. lower consumption (men [22% vs. 10.8%] and women [21.8% vs. 10.6%] of weight; gr/day) was associated with a higher risk of overall CVD (HR for 10% increase in proportion of UPF: 1.12; 95% CI: 1.05-1.20), coronary heart disease (HR: 1.13; 95% CI: 1.02-1.24) and cerebrovascular disease (HR: 1.11; 95% CI: 1.01-1.21). One US study (N=11,898) assessed the association between higher vs. lower consumption of UPF (<2.6 times per day vs. 5.2 to <29.8 times per day) and CVD mortality but reported no association (HR: 1.10; 95% CI: 0.74-1.67).	+ +/-
Cancer					
(9)	2021	SR / MA	UPF	In the prospective study higher consumption of UPF vs. lower consumption (men, 23.3% vs. 11.8%, and women, 23.4% vs. 11.8% of weight; gr/day) was associated with a higher risk of overall cancer (HR for 10% increase in proportion of UPF: 1.12; 95% CI: 1.06-1.18) and breast cancer (HR: 1.11; 95% CI: 1.02-1.22). However, no association was reported for prostate (HR: 0.98; 95% CI: 0.83-1.16) or colorectal cancer in this cohort (HR: 1.13; 95% CI: 0.92-1.38). The case-control study examining breast cancer risk alone assessed UPF consumption as a dichotomous variable; less than 5 days per week vs. more than 5 days per week (considered as less than regular vs. regular consumption, respectively). Regular consumption was associated with higher odds of breast cancer (OR: 2.35; 95% CI: 1.08-5.12). The second case-control study investigating prostate cancer alone reported no significant associations between higher vs. lower consumption of UPF (33% vs. 18% of calories) and prostate cancer (OR: 0.92; 95% CI: 0.72-1.17).	+ +/-
Diabetes					
(9)	2021	SR / MA	UPF	Higher consumption of UPF was associated with a higher risk of type 2 diabetes mellitus (HR for 10% increase in proportion of UPF: 1.15; 95% CI: 1.06-1.25).	+
Obesity					
(19)	2017	NR	UPF	Four of five studies found that higher purchases or consumption of UPF was associated with overweight/obesity.	+
(18)	2019	RCT	UPF	Higher weight gain during diet rich in UPF compared to unprocessed diet due to higher energy intake.	+

Ref.	Year	Study	Food Type	Results	Grade
(13)	2020	SR	UPF	Most studies (n=7) found a positive association among the consumption of UPF and abdominal obesity. In addition, four articles reported a dose-response gradient for this association i.e., the higher the consumption category of UPF, the higher the BMI averages and WC and the higher the risk of overweight, obesity, or abdominal obesity. Only one study did not observe a statistically significant relationship between UPF consumption and obesity measures.	+
(9)	2021	SR / MA	UPF	Consumption of UPF was associated with increased risk of overweight (OR: 1.36; 95% CI: 1.23-1.51; P < 0.001), obesity (OR: 1.51; 95% CI: 1.34-1.70; P < 0.001), abdominal obesity (OR: 1.49; 95% CI: 1.34-1.66; P<0.0001) in adults, based on 14 studies. Results were inconsistent for adolescents (4 studies, N=32,311). In children (2 studies, N=511) in one study consumption was not associated with BMI (beta coefficient: 0.00; 95% CI: −0.02 to 0.01), and in another, no difference in means between children with normal vs. excess weight in the percentage contribution of ultra-processed food (mean [SE]: 48.2% [1.4] vs. 49% [2.0], P=0.73) were found.	+
(7)	2021	Cross-sectional survey in CH	UPF	Women in the highest quintile of UPF weight proportion had significantly higher odds of having obesity (OR: 3.01, 95% CI: 1.48-6.11), having abdominal obesity (OR: 2.69, 95% CI: 1.43-5.05), and being in the highest category of the BMI-WC composite outcome (OR: 3.28, 95% CI: 1.59-6.77). No relevant associations were observed in men.	+

Summary result: + positive association between consumption and health outcome; +/- no association; - neg. association (inverse/ protective).
CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review

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2.12 Nuts, seeds and oleaginous foods

Author: Beatrice Baumer Reviewer: Pedro Marques-Vidal

2.12.1 Introduction

Whole nuts and seeds are botanically diverse parts of plants; however, as food items, they have common culinary uses and a comparable composition as source of fats, proteins, and dietary fibre in different ratios. According to the Swiss food composition database (1) standard composition per 100 g ranges are: energy 600-700 kcal, fat 45-67 g, protein 15-26 g, and fibre 6-10 g. This category is often a good source of micronutrients (e.g., magnesium 100-500 mg, vitamin E 2-34 mg tocopherol equivalents). Due to their high fat content, they are currently grouped together with the oils and fats in the “oil, fat and nuts” group in the Swiss food pyramid (2). Specific recommendations are one portion i.e., 20-30 g/day for unsalted nuts and seeds. Botanically, avocados are berries. Due to their higher fat content (14.2% according to the Swiss Food Composition Database (1)) they are also grouped together with “oil, fat and nuts”. The same goes for olives, *per se* fruits, albeit with a high fat content, which can vary depending on the processing conditions (15-17%, with the caveat that processing often also involves the addition of salt to amounts of 1.8-3.2%). There is no recommended portion size for avocado or olives, but it is mentioned that a small handful of olives or avocado can replace a soup spoon of oil.

In the previous FCN report (3), it was concluded that the regular intake of unsalted nuts is associated with a decreased incidence of NCD and total mortality, as based on prospective cohort studies. Furthermore, nut supplementation had a short-termed beneficial effect on cardiovascular risk factors, body weight, glucose homeostasis, and blood markers of inflammation, as recorded by numerous RCTs, already with 10 g servings. Based on these findings, the recommendation was that nuts should not be equated to animal fat sources in the Swiss food pyramid, due to their high fibre, protein, and micronutrient content. It was hence suggested that nuts might possibly be located at other/lower levels of the pyramid than oils and fats.

2.12.2 Search strategy

We searched PubMed and Cochrane databases for systematic reviews and meta-analyses focusing on nuts and seeds and NCD (CVD, cancer, T2D and obesity), but not for intermediate metabolic outcomes, such as blood pressure, changes in blood lipids etc. For PubMed, all studies related to adults (18+ years) published in English in the last five years were considered, using “nuts” and “food groups” as main search terms. Documents retrieved for “food groups” were then screened for “nuts” in the text and retained whenever nuts had been evaluated as a separate food group. The last specific report in the Cochrane library is of 2012 and was already considered for in the FCN report. The studies passing the first screening had their abstract screened and, in case of doubt, the full text was screened. A separate search, with the same filters, was performed for avocado and olives. The syntax is provided in the annex, chapter 2.12.

2.12.3 Main findings

Most studies included in the retrieved reviews/ meta-analyses did not specify the types of nuts included, but frequently the sub-group of “tree nuts” is mentioned (e.g., walnut, Brazil nut, hazelnut, almond); peanuts (sometimes also peanut butter) are often included, whereas coconuts are not.

No reviews or meta-analyses were found for selected seeds, i.e., sesame, linseed (flaxseed), sunflower, hemp, poppy, pumpkin, or chia seeds, although it is generally recognized that seeds can be an interesting source for a variety of bioactives (4). No study was found for olives or avocado with the applied filters; the results of a larger RCT performed in the USA have not yet been published (5).

2.12.3.1 Mortality

A regular intake of nuts up to 20 g/day reduces the mortality risk (6); other studies included in a meta-analysis show a risk decrease with a dose-response relationship, with no upper limits stated (7).

2.12.3.2 Cardiovascular disease

Although some larger observational studies show a risk reduction in CVD and mortality (PURE) (8), the evidence from meta-analyses is weak but leans towards a reduction of the risk of CVD and mortality (9-14). More studies are being performed as RCTs on intermediate metabolic risk factors; however, these were not taken into consideration.

2.12.3.3 Cancer

The ongoing World Cancer Research Fund data do not list any association, positive or negative between nuts and cancer, stating only “This Recommendation does not imply that all foods high in fat need to be avoided. Some, such as certain oils of plant origin, nuts, and seeds, are important sources of nutrients. Their consumption has not been linked with weight gain and by their nature they tend to be consumed in smaller portions” (15). Some recent papers find an inverse association between nut intake and cancer mortality (16, 17), others only in the analysis of sub-groups, i.e., for colon cancer (17)

A potential issue linking nuts with cancer risk is whenever an aflatoxin contamination has occurred, this is a food safety issue not further discussed here.

2.12.3.4 Diabetes

No specific studies were retrieved.

2.12.3.5 Obesity

Although rich in fats, nut consumption is not associated with weight gain. Some studies show that regular consumption of nuts is inversely associated with some obesity parameters (18-21).

2.12.4 Conclusion

No data was retrieved for seeds; this food group needs further investigation, as well as do fruit containing higher amounts of fat (avocado and table olives). The consumption of nuts in typical servings (10-28 g) is not associated with higher risks for the NCD considered. On the contrary, an inverse association has been observed with mortality, CVD, some obesity parameters, and some cancer types. The level of evidence is low, and some discrepancy in the data exists. In particular some studies show a dose-dependent association, whilst others found no additional benefit with intakes above 10 g/day.

Table 36: Summary nuts, seeds and oleaginous foods intake and risk of NCD

Conclusion	Class	Level
Nut consumption decreases mortality risk	I	A
Nut consumption of at least 10 g/day decreases the risk of CVD	I	A
Nut consumption might decrease the risk of certain cancers	II	B/C
Nut consumption does not increase the risk of obesity	I	A/B
Nut consumption might decrease the risk of obesity	II	A/B

2.12.5 Recommendations

The most recent data do not justify changing the current recommendation per portion size, due to the fact the possible beneficial effects might be due to components other than fat, the question of the correct placement of nuts in the pyramid remains open for discussion. Furthermore, many papers mention the allergenic potential of nuts as a precaution. Finally, it should be stressed that the recommendations apply to unsalted nuts.

Table 37: Estimation of minimum, optimal, and maximum amount of nuts, seeds and oleaginous foods intake in relation to NCD

Food group	NCD	Minimum	Maximum	Optimal
Nuts	CVD	10 g/day	-	-
Nuts	Cancer	-	-	-
Nuts	T2D	-	-	-
Nuts	Obesity	-	-	-

-, not defined.

Table 38: Results of the associations between nuts, seeds and oleaginous foods and health outcomes

Ref.	Year	Study	Food Type	Results	Grade
Mortality					
(6)	2017	SR / MA of PCS	High-low comparison	With increasing intake (for each daily serving) of nuts (RR: 0.76; 95% CI: 0.69-0.84), the risk of all-cause mortality decreased. The risk of all-cause mortality decreased by approx.17% with increasing intake of nuts up to approx. 15-20 g/day. No benefit was apparent when increasing intake above this value.	IA
(7)	2020	SR / MA of systematic reviews and MAs	All nuts (per 28 g/day), tree nuts (per 10 g/ d, peanuts (per 10 g/d)	Nuts were associated with a reduced risk of mortality in a dose-response relationship (all nuts: RR: 0.78; 95% CI: 0.72-0.84; tree nuts: RR 0.82; 95% CI: 0.75-0.90; and peanuts: RR: 0.77; 95% CI: 0.69-0.86).	IA
Cardiovascular disease					
(9)	2019	SR / MA of 19 PCS	Nuts (in general not specified)	The results revealed an inverse association between total nut consumption (comparing highest vs lowest categories) and CVD incidence (RR: 0.85; 95% CI: 0.80-0.91; I^2=0%), CVD mortality (RR: 0.77; 95% CI: 0.72-0.82; I^2=3%), coronary heart disease (CHD) incidence (RR: 0.82; 95% CI: 0.69-0.96; I^2=74%), CHD mortality (RR: 0.76; 95% CI: 0.67-0.86; I^2=46%), stroke mortality (RR: 0.83; 95% CI: 0.75-0.93; I^2=0%), and atrial fibrillation (RR: 0.85; 95% CI: 0.73-0.99; I^2=0%). No association was observed with stroke incidence and heart failure. The certainty of the evidence ranged from moderate to very low. Conclusions: This systematic review and meta-analysis revealed a beneficial role of nut consumption in reducing the incidence of, and mortality from, different CVD outcomes.	IIB
(10)	2017	MA of 18 PCS	3 servings per week (serving =12 g)	The random-effects summary RRs for high compared with low nut consumption were 0.81 (95% CI: 0.78-0.84) for all-cause mortality (18 studies with 81,034 deaths), 0.75 (95% CI: 0.71-0.79) for CVD mortality (17 studies with 20,381 deaths), 0.73 (95% CI: 0.67-0.80) for CHD mortality (14 studies with 10,438 deaths), 0.82 (95% CI: 0.73-0.91) for stroke mortality (13 studies with 4,850 deaths) and 0.87 (95% CI: 0.80-0.93) for cancer mortality (11 studies with 21,353 deaths).	
(11)	2018	Review of MA		Nut consumption appears to be associated with reduced all-cause mortality by 19-20% (n=6), CVD incidence (19%; n=3) and mortality (25%; n=3), coronary heart disease (CHD) incidence (20-34%; n=2) and mortality (27-30%; n=2), and stroke incidence (10-11%; n=7) and mortality (18%; n=2).	
(13)	2020	Summary of 3 PCS	0.5 serving/day	Per 0.5 serving/day increase in total nut consumption was associated with lower risk of CVD (RR: 0.92; 95% CI: 0.86-0.98), coronary heart disease (RR: 0.94; 95% CI: 0.89-0.99), and stroke (RR: 0.89; 95% CI: 0.83-0.95). Compared with individuals who remained non-consumers	IB

Ref.	Year	Study	Food Type	Results	Grade
				in a 4-year interval, those who had higher consumption of total nuts (≥0.5 servings/day) had a lower risk of CVD (RR: 0.75; 95% CI: 0.67-0.84), coronary heart disease (RR: 0.80; 95% CI: 0.69-0.93), and stroke (RR: 0.68; 95% CI: 0.57-0.82) in next 4 years. Individuals who decreased nut consumption by ≥0.50 servings/day had a higher risk of developing CVD (RR: 1.14; 95% CI: 0.99-1.32), coronary heart disease (RR: 1.06; 95% CI: 0.88-1.28), and stroke (RR: 1.28; 95% CI: 1.02-1.60) when compared with those who maintained their nut consumption.	
(14)	2021	UR		Out of the six meta-analyses focussed on legume and 15 on nut intake, a possible association with decreased risk of colorectal adenoma and coronary heart disease was found for higher legume consumption, and a decreased risk of cardiovascular and cancer mortality, colon cancer, hypertension, and ischaemic stroke for higher nut consumption. The association between legume consumption and CVDs, as well as nut consumption and risk of cancer, CVD incidence and all-cause mortality, was deemed as "limited" due to heterogeneity between results and/or potential confounding factors. General benefit towards better health can be observed for nut and legume consumption. Further studies are needed to better elucidate potential confounding factors.	IIA
Cancer					
(16)	2021	MA of observational studies	Tree nuts	In total, 43 articles on cancer risk and 9 articles on cancer mortality were included in the current systematic review and meta-analysis. The summary effect size (ES) for risk of cancer, comparing the highest with lowest intakes of total nuts, was 0.86 (95% CI: 0.81-0.92, p<0.001, I^2=58.1%; p<0.01), indicating a significant inverse association. Such a significant inverse association was also seen for tree nut intake (pooled ES: 0.87; 95% CI: 0.78-0.96, p<0.01, I^2=15.8%; p=0.28). Based on the dose-response analysis, a 5-g/day increase in total nut intake was associated with 3%, 6%, and 25% lower risks of overall, pancreatic, and colon cancers, respectively. In terms of cancer mortality, we found 13%, 18%, and 8% risk reductions with higher intakes of total nuts, tree nuts, and peanuts, respectively. In addition, a 5-g/day increase in total nut intake was associated with a 4% lower risk of cancer mortality.	IB
(17)	2020	MA	Nut serving 15 g/day	We included 38 studies on nut consumption and cancer risk and 9 studies on cancer-specific mortality. Compared with no nut intake, nut intake was associated with a lower cancer risk (RR: 0.90; 95% CI: 0.86-0.94). Inverse associations were observed with colorectal cancer, gastric cancer, pancreatic cancer, and lung cancer in subgroup analyses. Tree nut consumption was found to reduce cancer risk (RR: 0.88; 95% CI: 0.79-0.99). Dose-response curves suggested that protective benefits against cancer increased with increased nut intake (p=0.005, P-nonlinearity=0.0414). An inverse correlation with cancer-specific mortality (OR: 0.90; 95% CI: 0.88-0.92) was observed.	
(22)	2018	MA		Six studies with 7,283 CRC cases were included in the high vs. low intake meta-analysis (overall intake range: 0-22 g/day) No association was observed for the highest vs. lowest nut intake category (RR: 0.96; 95% CI: 0.90-1.02) or for each additional 28 g/day (RR: 0.96; 95%	IIB

Ref.	Year	Study	Food Type	Results	Grade
				CI: 0.76-1.21). In an additional subgroup analysis, an inverse association for colon, but not for rectal cancer was observed.	
Type 2 Diabetes					
(11)	2018	Review of MA		No association between nut consumption and the risk of T2D was observed in MA of prospective studies.	
Obesity					
(20)	2021	MA of PCS and RCTs	Median nut intake at baseline in the highest quantiles of consumers was estimated at 7 g/day ranging from 3 to ≥28 g/day.	Nuts were associated with lower incidence of overweight/obesity (RR: 0.93; 95% CI: 0.88-0.98; p<0.001, “moderate” certainty of evidence) in prospective cohorts. RCTs presented no adverse effect of nuts on body weight (MD: 0.09 kg; 95% CI: -0.09, 0.27 kg; p<0.001, “high” certainty of evidence). Meta-regression showed that higher nut intake was associated with reductions in body weight and body fat.	
(19)	2021	SR / Network MA of RCTs		A random-effects network meta-analysis was conducted following the PRISMA-NMA statement. A total of 105 RCTs with measures of BW (n=6,768 participants), BMI (n=2918), WC (n=5045), and BF% (n=1226) were included. The transitivity assumption was met based on baseline characteristics. In the comparisons of nut consumption versus a control diet, there was no significant increase observed in any of the obesity-related measures examined except for hazelnut-enriched diets, which raised WC. Moreover, almond-enriched diets significantly reduced WC compared to the control diet and to the pistachio-, mixed nuts-, and hazelnut-enriched diets. In subgroup analyses with only RCTs, designed to assess whether nut consumption affected weight loss, almonds were associated with reduced BMI and walnuts with reduced %BF. The evidence supports that: (1) tree nut and peanut consumption do not influence obesity, and (2) compared to a control diet, the consumption of almond-enriched diets was associated with a reduced waist circumference.	low
(18)	2020	SR / MA	walnuts	A total of 27 articles were included in this meta-analysis, with walnuts dosage ranging from 15 to 108 g/day for 2 weeks to 2 years. Overall, interventions with walnut intake did not alter waist circumference (WC) (WMD: -0.193 cm, 95 % CI: -1.03, 0.64, p=0.651), body weight (BW) (0.083 kg, 95 % CI: -0.032, 0.198, p=0.159), BMI (WMD: -0.40 kg/m^2; 95 % CI: -0.244, 0.164, p=0.703), and fat mass (FM) (WMD: 0.28%, 95% CI: -0.49, 1.06, p=0.476). Following dose-response evaluation, reduced BW (Coef.= -1.62, p=0.001), BMI (Coef.= -1.24, p=0.041) and	

Ref.	Year	Study	Food Type	Results	Grade
				WC (Coef.= -5.39, p=0.038) were significantly observed through walnut intake up to 35 g/day. However, the number of studies can be limited as to the individual analysis of the measures through the dose-response fashion.	
(21)	2019	SR / MA	Dose-response, by 28 g increments	Summary RRs and 95% CIs were estimated from 3 reports for the highest compared with the lowest intake categories, as well as for linear and nonlinear relations focusing on each outcome separately: overweight/obesity, abdominal obesity, and weight gain. The quality of evidence was evaluated with use of the NutriGrade tool. In the dose-response MA, inverse associations were found for nut (RR for abdominal obesity: 0.42; 95% CI: 0.31-0.57).	IA
(11)	2018	Review of MA		Nut consumption did not significantly affect body weight.	

CCS: Case control studies; MA: Meta-analysis; PCS: Prospective cohort studies; R: Review; RCT: Randomized controlled trial; SR: Systematic review; UR, umbrella review

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2.13 Oils and fats

Author: Pedro Marques-Vidal   Reviewer: Suzanne Suggs

2.13.1 Introduction

Oils and fats are the most caloric foods, providing nine kilocalories per gram. Fats and oils are made of triglycerides, i.e. a glycerol molecule to which three fatty acids are ligated via ester bounds. Those fatty acids can be categorized into four groups: saturated (SFA), cis-monounsaturated (MUFA), cis-polyunsaturated (PUFA), and *trans* fatty acids (TFA). Fats composed mainly of SFA and TFA are solid at room temperature (butter, lard, margarine...), while fats composed mainly of MUFA and PUFA are liquid at room temperature (olive, sunflower or canola oils...). Most solid fats are from animal origin, while most oils are from vegetal origin.

The current Swiss dietary recommendations are ambiguous regarding fat intake: the DACH reference values suggest that fat intake should not exceed 30% of the TEI (1), while the Swiss federal commission for nutrition recommends a maximum of 40% of the TEI (90 g per day for a TEI of 2000 kcal) (2). The federal commission also recommends that SFA represent <10% and MUFA <20% of the TEI. The Swiss food pyramid recommends that fats from vegetal sources be consumed preferably to animal fats (3). In this review, we will not consider nuts or seeds, which have been reviewed elsewhere.

In the previous report of the FCN, meta-analyses up to 2016 were analysed (4). Total fat and SFA were not associated with CVD morbidity or mortality. Replacement of SFA by PUFA led to a small but potentially important benefit regarding CVD. Seafood-derived n-3 PUFA were associated with a reduction of CHD risk and CHD death. The strongest association was between TFA and increased CHD risk. High intake of total fat and of SFA was associated with increased risk of cancer of breast, endometrium and stomach in some but not all studies, but only five studies were available and most focused on female cancers. Total or SFA intake were not clearly associated with increased risk of T2D, while increased consumption of MUFA, olive oil and in some instances of PUFA were associated with reduced T2D risk. Finally, lowering the proportion of fat in the diet resulted in a small but noticeable decrease of body weight. No studies on the effects of specific oils (i.e. canola, palm) or fats (lard, butter) were provided. It should be noted that the previous report of the FCN focused on fatty acids, very few studies being presented regarding oils or fatty foods (4); for instance, the neutral effect of butter on CVD and T2D was not detailed (5). Hence, given the lack of studies focusing on fatty foods, it was decided to include this into this paper.

2.13.2 Search strategy

We searched PubMed and Cochrane databases for all systematic reviews and meta-analyses focusing on oils and fats and NCD (CVD, cancer, T2D and obesity). For PubMed, all studies related to adults (18+ years) published in English in the last five years were considered. For Cochrane, we extended the research period to the last 10 years, as the number of hits in the last 5 years was limited. Titles were screened and a first selection was performed. The studies passing the first screening had their abstract screened and, in case of doubt, the full text was screened. The syntax is provided in the annex, chapter 2.13.

Studies on specific diets (Mediterranean, Nordic, other) were excluded as it was not possible to identify the specific effects of the fat components of those diets. Studies focusing on specific populations (i.e., children, pregnant or lactating women, elderly…) were also excluded.

2.13.3 Main findings

2.13.3.1 <u>Cardiovascular disease</u>

Total fat intake was not associated with CVD or CHD mortality (6). Reducing SFA had no effect on CVD or CHD mortality or non-fatal AMI, but reduced the risk of combined CVD events (7). SFA intake was associated with increased CHD mortality (6) and a decreased risk of stroke (8). MUFA intake was not associated with CVD or CHD mortality but decreased the risk of stroke (6). PUFA intake was not associated with CVD mortality in one study (6), while a protective effect was found in another (9). PUFA was not associated with CHD mortality (6). PUFA intake decreased the risk of stroke (6), while no significant association was found for other CVD events (10). Replacing SFA by PUFA led to a decrease in CVD events (11). TFA intake was associated with increased mortality from CVD.

Fish or plant-based omega-3 supplementation had no effect on CVD in one study (12). Alpha linolenic acid (an omega-3 fatty acid) intake was associated with lower risk of CVD and CHD (13). No association between omega-6 intake and CVD events was found (14).

Palm oil intake increased the risk of AMI (15). An increase of 14 g/day of butter consumption had no effect on CVD (5).

2.13.3.2 Cancer

Several meta-analyses conducted before 2018 but not mentioned in the FCN report were found (16-19). Hence, for completion, they were included in the current report.

Four meta-analyses focused on cancer mortality (7, 9, 13, 17), three on breast cancer (16, 20, 21), two on prostate cancer (18, 22), and one for bladder (23), skin (24), endometrium (19), testis (25) and pancreas (26).

Total fat intake was associated with increased bladder cancer risk (23), but not with skin cancer (24). Increased SFA intake was positively associated with cancer mortality in one study (9) but not in another (7) and had no association with skin cancer (24). MUFA intake exerted a protective effect against basal cell skin carcinoma (24). PUFA intake increased the risk of squamous cell carcinoma (24) and decreased the risk of pancreatic cancer (26). ALA intake increased the risk of cancer mortality (13). TFA intake increased the risk of prostate and colorectal cancer but not for breast or ovarian cancer or non-Hodgkin lymphoma (22).

Fish oil intake was not associated with prostate cancer, but results were inconsistent, and no summary results of the meta-analysis were provided (18). Vegetable oil intake had no effect on breast cancer (16). Olive oil intake decreased the risk of breast cancer in one study (16) but not in another (21). Butter intake increased the risk of endometrial cancer (19) but had no effect on cancer mortality (17) or testicular carcinoma (25).

2.13.3.3 Diabetes

SFA intake exerted a protective effect against T2D in one study (27) and had no effect in two others (7, 28). MUFA intake increased the risk of T2D in one study (29). PUFA intake exerted a protective effect against T2D in one study (29) and had no effect in two others (27, 30). TFA intake had no effect T2D incidence in one study (28). Omega-3 fatty acids intake decreased the risk of T2D in one study (31) had no effect in another (30) and increased the risk in another (27). ALA intake showed a borderline significant protective effect in one study (27), while another study could not conclude as the evidence was of very low quality (30). Omega-6 fatty acids intake exerted a protective effect against T2D in one study (29), and had no effect in another (30).

Vegetable fat intake was inversely related with incidence of T2D in one study (27). Similarly, olive oil intake reduced the risk of T2D (32). Butter consumption was also associated with a decreased risk of T2D (5).

2.13.3.4 Obesity

Two meta-analyses reported that SFA reduction (33) or replacement (7) led to decreases in weight. No effect of PUFA, omega-6 or coconut oil intake on weight parameters was found.

2.13.4 Conclusion

The interpretation of the findings is complicated because intervention studies either reduced, supplemented, or replaced some types of fat. Further, some studies focused on a specific type of fat (oil or fatty acid). Studies focusing on olive, palm or coconut oil were conducted in countries that are major producers of such oils; hence, a possible conflict of interest cannot be excluded. Finally, for a single study, different conclusions could be obtained regarding the type of fat considered (i.e., SFA or PUFA).

Table 39: Summary oils and fatty foods intake and risk of NCD

Conclusion	Class	Level
Total fat		
Total fat is not associated with CVD	II	A
Total fat might increase cancer (bladder)	III	B
Saturated fat		
SFA might be associated with CVD	III	A
SFA might increase cancer	III	B
SFA might protect against diabetes	I	B
SFA might increase weight	III	A
Monounsaturated fat		
MUFA might protect against stroke	I	B
MUFA might protect against cancer (skin)	I	B
MUFA might be associated with diabetes	III	B
Polyunsaturated fat		
PUFA might protect against CVD	I	A
PUFA effect appears cancer-specific	II	A
PUFA might protect against diabetes	I	B
PUFA is not associated with obesity	II	B
***Trans* fat**		
TFA are associated with CVD	III	A
TFA might increase cancer (prostate, colon)	III	B
TFA are not associated with diabetes	II	B
Omega fats		
Omega-3 might protect against CVD	I	A
Omega-3 effect on diabetes is unclear	II	A
Omega-6 are not associated with CVD	II	B
Omega-6 might protect against diabetes	I	B
Omega-6 are not associated with obesity	II	B
Animal fat		
Butter is not associated with CVD	II	B
Butter might increase cancer (endometrium)	III	B
Butter might protect against diabetes	I	B
Vegetable fat		
Vegetable oil is not associated with cancer	II	B
Vegetable fat might protect against diabetes	I	B
Olive oil might protect against cancer	I	B
Olive oil might protect against diabetes	I	A
Palm oil is associated with CVD	III	B
Coconut oil is not associated with obesity	II	B

2.13.5 Recommendations

The results of studies focusing on a specific type of fat (i.e., SFA, PUFA) are difficult to apply in practice as people do not consume specific fatty acids, except as supplements. All oils and fatty foods are a mixture in varying proportions of SFA, MUFA and PUFA (34). The fatty acid content of butter varies according to the production system (conventional, organic, or grass) (35); the fatty acid content of canola oil varies according to production, genetic and sowing period (36), and the PUFA content of farmed salmon is higher than of wild type, although at the expense of a higher SFA content (37). Varying the sources of fat, with a higher intake of vegetable-based sources, will ensure an adequate balance of fatty acid intake and contribute to a healthy diet, as already indicated in the previous FCN report (4). Also, to keep an isocaloric diet, increased consumption of caloric-rich fatty foods must be done by decreasing the intake of other foods.

Providing absolute amounts of fatty foods and oils that should be consumed is a hard task, as few studies provided dose-response relationships; further, most associations were non-linear, suggestive of a ceiling effect. Finally, the protective effect of one fatty food towards one disease should be balanced against the possible deleterious effects on other diseases. For example, SFA intake might protect against stroke (8) but is associated with increased cancer mortality in a linear pattern if intake exceeds 3% of total energy (9).

A meta-analysis of prospective cohort studies concluded that a 10 g/day increase in SFA would lead to a 6% decrease in the risk of stroke, the decrease being effective till 24 g/day (8). Still, the 95% CI boundaries were large and included unity. A 1 g/day increase in alpha-linolenic acid intake (equivalent to one tablespoon of canola oil/day) was associated with a 5% lower risk of all cause and CVD mortality, but the effect did not increase further after 2 g/day (13).

Each consumption of 1 g/day TFA was not associated with increased risk of breast cancer (20), but no dose-response curve of the effect was provided; the intake of 14 g/day olive oil also had no effect on breast cancer risk (21). A decrease in breast cancer risk was observed for vegetable oil intake between 0 and 20 g/day, but the 95% CI included unity (16)

In a systematic review and dose-response meta-analysis of prospective observational studies the effect on T2D of PUFA and TFA daily intakes between 0 and 25 g (SFA and MUFA); 0 and 13 g (PUFA) and 0-3 g (TFA) was assessed (27). SFA intake between 20 and 25 g/day was associated with a decreased risk for T2D, an increased MUFA and PUFA intake was associated with an increased risk, and no effect was found for TFA. The new studies contradict the previous FCN report, where intake of PUFA and PUFA was associated with a decreased T2D risk (4). Still, the boundaries of the 95% CI of the effects of MUFA and PUFA in the new studies included unity. The issue was further complicated as the dose-response profiles for each fatty acid varied considerably, from a U-shape for linoleic and alpha-linoleic acid to an inverted U-shape for eicosapentanoic and docosaexanoic acid; only long-chain omega-3 fatty acid intake appeared to exert a deleterious effect starting at a consumption of 250 mg/day. Finally, vegetable fat intake exerted a protective effect starting at 5 g/day, which reached its maximum at 13 g/day a remained stable till 35 g/day, while animal fat intake tended to exert a deleterious effect, namely at intakes higher than 25 g/day (27).

The current recommendations from the Swiss food pyramid are to consume 20 to 30 g/day of vegetable oil, of which half should be canola, and 10 g/day of butter or cream (38), which is in line with the findings. The previous FCN recommendation to reduce butter (4) is not confirmed by the current evidence. The data collected do not allow indicating which type of vegetable oil should be preferred; as already stated in the previous FCN report, "the choice of canola (rapeseed) oil lacks scientific evidence and is of historical origin" (4), because no other locally available oil would allow an adequate intake of n-3 fats.

Table 40: Estimation of minimum, optimal, and maximum amount of oils and fatty foods intake in relation to NCDs.

Food group	**NCD**	**Minimum**	**Maximum**	**Optimal**
Animal fats	CVD	-	-	-
Animal fats	Cancer	-	-	-
Animal fats	T2D	-	25 g/day	-
Animal fats	Obesity	-	-	-
Vegetal fats	CVD	1 tablespoon oil *	3 tablespoons	2 tablespoons
Vegetal fats	Cancer	0 g/day	20 g/day	-
Vegetal fats	T2D	5 g/day	35 g/day	13 g/day
Vegetal fats	Obesity	-	-	-

-, not defined; *, providing 1 g of alpha-linolenic acid, 1 tablespoon= 10 g oil

Table 41: Results of the associations between oils and fatty foods and health outcomes

Ref.	Year	Study	Food Type	Results	Grade
Cardiovascular diseases					
(9)	2021	SR / MA	Fat, all types	19 studies included. A 5% increase in energy from PUFA was associated with 5% (RR: 0.95; 95% CI: 0.91-0.98) lower mortality from CVD. A 1% energy increment in dietary TFA was associated with 6% higher risk of mortality from CVD (RR: 1.06; 95% CI: 1.02-1.11).	IA (PUFA) III (TFA)
(6)	2020	MA	Fat, all types	29 studies included. No association was observed between total fat and CVD (RR: 0.93, 95% CI: 0.80-1.08) or CHD mortality (RR: 1.03 95% CI: 0.99-1.09). An association between SFA intake and CHD mortality (RR: 1.10, 95% CI: 1.01-1.21) was observed. Neither MUFA nor PUFA were associated with CVD or CHD mortality. Inverse associations were observed between MUFA (RR: 0.80, 95% CI: 0.67-0.96) and PUFA (RR: 0.84, 95% CI: 0.80-0.90) intakes and stroke mortality.	IA (MUFA, PUFA and stroke) IIA (MUFA, PUFA and CVD) IIIA (SFA and CHD)
(11)	2021	SR / MA	Fat, all types	6 studies on subjects with T2D. Replacement of SFA for 2% energy replacement with PUFA (RR: 0.87, 95% CI: 0.77-0.99) or carbohydrate (RR: 0.82, 0.67-1.00) was associated with reduced CVD occurrence. Higher PUFA:SFA intake was also associated with reduced CVD occurrence (RR: 0.75, 95% CI: 0.57-0.98). The quality of evidence was low to very-low.	IA (PUFA) IIIA (SFA)
(8)	2020	SR / MA	SFA	14 studies included. Higher dietary SFA intake was associated with a decreased overall risk for stroke (RR: 0.87; 95% CI, 0.78-0.96). The pooled RR of stroke per 10 g/day increase in SFA intake was 0.94 (95% CI: 0.89-0.98).	IA
(7)	2020	SR / MA	SFA replacement	15 RCTs included. Reducing dietary SFA reduced the risk of combined CVD events (RR: 0.83; 95% CI: 0.70-0.98). Greater reductions in SFA (reflected in greater reductions in serum cholesterol) resulted in greater reductions in risk of CVD events. Little or no effect of reducing SFA on CVD mortality (RR: 0.95, 95% CI: 0.80-1.12), non-fatal AMI (RR: 0.97, 95% CI: 0.87-1.07) or CHD mortality (RR: 0.97, 95% CI: 0.82-1.16). Effects on total (fatal or non-fatal) AMI, stroke and CHD events (fatal or non-fatal) were unclear as the evidence was of very low quality.	IA (combined) IIA (other)
(10)	2018	SR / MA	PUFA	49 RCTs included, 11 were at low summary risk of bias. Increasing PUFA slightly reduces risk of CHD (RR: 0.87, 95% CI: 0.72-1.06) and CVD events (RR: 0.89, 95% CI: 0.79-1.01). Increasing PUFA may slightly reduce risk of CHD death (RR: 0.91, 95% CI: 0.78-1.06) and stroke (RR: 0.91, 95% CI: 0.58-1.44, though confidence intervals include important harms), but has little or no effect on CVD mortality (RR: 1.02, 95% CI: 0.82-1.26)	IA
(12)	2018	SR / MA	Fish and plant based omega-3	79 RCTs included, 25 were at low summary risk of bias. Most studies assessed LCn3 supplementation with capsules, but some used LCn3- or ALA-rich or enriched foods or dietary	IIA

Ref.	Year	Study	Food Type	Results	Grade
				advice compared to placebo or usual diet. Meta-analysis suggested little or no effect of increasing LCn3 on CVD mortality (RR: 0.95, 95% CI: 0.87-1.03), CVD events (0.99, 95% CI: 0.94-1.04), CHD mortality (0.93, 95% CI: 0.79-1.09) or stroke (1.06, 95% CI: 0.96-1.16) Increasing ALA intake probably makes little or no difference to CVD mortality (RR: 0.96, 95% CI: 0.74-1.25) and CHD mortality (RR: 0.95, 95% CI: 0.72-1.26), and may make little or no difference to CHD events (RR: 1.00, 95% CI: 0.80-1.22). Moderate- and high-quality evidence suggests that increasing EPA and DHA has little or no effect on cardiovascular health. Low-quality evidence suggests ALA may slightly reduce CVD events.	
(13)	2021	SR / MA	ALA	41 studies included. High intake of ALA was associated with a lower CVD (RR: 0.92, 95% CI: 0.86-0.99) and CHD (RR: 0.89, 95% CI: 0.81-0.97). In the dose-response analysis, a 1 g/day increase in ALA intake (equivalent-one tablespoon of canola oil or 0.5 ounces of walnut) was associated with a 5% lower risk of CVD mortality (RR: 0.95, 95% CI: 0.91-0.98).	IA
(14)	2018	SR / MA	Omega-6	19 RCTs included. Low-quality evidence that increased intake of omega-6 may make little or no difference to CVD events (RR: 0.97, 95% CI: 0.81-1.15). Uncertainty whether increasing omega-6 fats affects CVD mortality (RR: 1.09, 95% CI: 0.76-1.55), CHD events (RR: 0.88, 95% CI: 0.66-1.17), major adverse cardiac and cerebrovascular events (RR: 0.84, 95% CI: 0.59-1.20) or stroke (RR: 1.36, 95% CI: 0.45-4.11), as the evidence was of very low quality. No evidence of dose-response or duration effects for any primary outcome, but there was a suggestion of greater protection in participants with lower baseline omega-6 intake across outcomes. Increased intake of omega-6 fats may reduce AMI risk (RR: 0.88, 95% CI: 0.76-1.02).	IIA
(15)	2018	SR	Palm oil	5 studies included. Palmitic acid was associated with risk of AMI (OR: 2.76, 95% CI: 1.39-5.47). Total SFA intake was not associated with risk of AMI. Odds of developing first non-fatal AMI was higher in palm oil compared to soybean oil with 5% trans-fat (OR: 1.33, 95% CI: 1.09-1.62) than palm oil compared to soybean oil with 22% trans-fat (OR: 1.16, 95% CI: 0.86-1.56). The evidence for the outcomes of this review were all graded as very low.	IIB
(5)	2017	SR / MA	Butter	5 studies included. Butter consumption was not significantly associated with any cardiovascular disease (RR: 1.00; 95% CI: 0.98-1.02), coronary heart disease (RR: 0.99; 95% CI: 0.96-1.03), or stroke (RR: 1.01; 95%CI: 0.98-1.03).	IIB

Ref.	Year	Study	Food Type	Results	Grade
Cancer					
(9)	2021	SR / MA	Fat all types, cancer mortality	A 5% increase in energy from PUFA was associated with a 4% (RR: 0.96; 95% CI: 0.94-0.99) lower mortality from cancer. The risk of cancer mortality increased by 4% for every 5% increase in TEI from SFA (RR: 1.04; 95% CI: 1.02-1.06).	IA (PUFA) IIIA (SFA)
(26)	2021	NR	Fat all types, pancreatic cancer	Numerous studies suggest that diets high in omega-3 PUFA are associated with reduced pancreatic cancer risk. However, the current evidence appears insufficient for a general conclusion regarding the impact of other types of fat in pancreatic carcinogenesis, with many studies providing inconclusive findings due to study limitations.	IIC
(23)	2019	MA	Fat all types, bladder cancer	10 studies included. The highest category of dietary fat intake could increase the risk of bladder cancer (RR: 1.279, 95% CI: 1.036-1.577). A positive association was found among European populations (RR: 1.359, 95% CI: 1.027-1.798), but not in North American populations. The association was not significant in the subgroup analysis by fat type or bladder cancer risk.	IIIB
(24)	2020	SR / MA	Fat all types, skin cancer	12 studies included. Dietary intake of total fat and SFA were not associated with three major types of skin cancer. High intake of MUFA was significantly associated with a decreased risk of basal cell carcinoma (RR: 0.90, 95% CI: 0.85-0.96) and high level of PUFA intake was potentially positively associated with squamous cell carcinoma (RR: 1.19, 95% CI: 1.06-1.33).	IIB (Total and SFA) IA (MUFA) IIIA (PUFA)
(7)	2020	SR / MA	SFA, cancer mortality	There was little or no effect on cancer mortality or cancer diagnoses.	IIA
(22)	2021	SR / MA	TFA, prostate cancer	46 studies included. Significant positive association for prostate cancer (OR: 1.49; 95% CI: 1.13-1.95) and colorectal cancer (OR: 1.26; 95% CI: 1.08-1.46) but not for breast cancer (OR: 1.12; 95% CI: 0.99-1.26), ovarian cancer (OR: 1.10; 95% CI: 0.94-1.28), or non-Hodgkin lymphoma (OR: 1.32; 95% CI: 0.99-1.76).	IIIA (prostate and colon) IIA (others)
(20)	2020	SR / MA	TFA, breast cancer	7 studies included. No relationship between dietary intake of TFA and breast cancer (RR: 1.02, 95% CI: 0.95-1.10). Based on 5 effect sizes, each additional 1 g/day dietary intake of TFA was not associated with breast cancer (RR: 1.00; 95% CI: 0.99-1.01).	IIA
(18)	2017	SR / MA	Fish omega-3, prostate cancer	54 studies included. The interventional studies using fish oil supplements in patients with PrCa showed no impact on prostate-specific antigen levels. Cohort and case-control studies assessing the relationship between dietary fish intake and the risk of PrCa were equivocal. Cohort studies assessing the risk of PrCa mortality suggested an association between higher intake of fish and decreased risk of prostate cancer-related death.	IIA

Ref.	Year	Study	Food Type	Results	Grade
(13)	2021	SR / MA	ALA, cancer mortality	41 studies included. High intake of ALA was associated with a slightly higher risk of cancer mortality (RR: 1.06, 95% CI: 1.02-1.11).	IIIA
(16)	2015	MA	Vegetable oils, breast cancer	16 studies included. Compared with the lowest vegetable oils intake, higher intake did not increase the risk of breast cancer (OR: 0.88, 95% CI: 0.77-1.01), and the result from dose-response analyses did not show a trend on the breast cancer risk for each 10 g vegetable oil/day increment (OR: 0.98, 95% CI: 0.95-1.01). Higher olive oil intake showed a protective effect against breast cancer with OR of 0.74 (95% CI: 0.60-0.92), which was not significant among the three cohort studies.	IIB IB (olive)
(21)	2021	SR / MA	Olive oil, breast cancer	10 studies included. The summary OR comparing women with the highest intake to those with the lowest category of olive oil intake was 0.48 (95% CI: 0.09-2.70) in prospective studies and 0.76 (95% CI: 0.54-1.06) in case-control studies, with substantial study heterogeneity. There was no significant dose-response relationship for olive oil and breast cancer risk; the OR for a 14 g/d increment was 0.93 (95% CI: 0.83-1.04).	IIA
(17)	2016	SR / MA	Butter, cancer mortality	1 study assessed the effect of butter. The overall RR was 1.13 (95% CI: 0.89-1.44)	IIB
(25)	2018	SR	Butter, testicular carcinoma	1 study included. Comparison between the 4th and the first quartile of butter intake led to an OR of 1.11 (95% CI: 0.83-1.48).	IIB
(19)	2017	SR / MA	Butter, endometrial cancer	2 studies included. The overall OR was 1.14 (95% CI: 1.03-1.26).	IIIB
Diabetes					
(27)	2020	SR / MA	Fat, all types	23 studies included. The protective association for vegetable fat and T2D was steeper at lower levels up to 13 g/d (sRR: 0.81, 95% CI: 0.76-0.88) than at higher levels. SFA showed an apparent protective association above intakes around 17 g/d (RR: 0.95, 95% CI: 0.90-1.00). There was a nonsignificant association of a decrease in T2D incidence for PUFA intakes up to 5 g/d (0.96, 0.91-1.01), and for alpha-linolenic acid intake up to 560 mg/d (RR: 0.95, 95% CI: 0.90-1.00), after which the curve rose slightly, remaining close to no association. The association for long-chain omega-3 fatty acids and T2D was approximately linear for intakes up to 270 mg/d (RR: 1.10, 95% CI: 1.06-1.15), with a flattening curve thereafter. Certainty of evidence was very low to moderate.	IA (vegetable fat and SFA) IIB (others)

Ref.	Year	Study	Food Type	Results	Grade
(31)	2018	R	Fat, all types	The intake of fish and marine n-3 fatty acids among Asian populations and trans-palmitoleic acid (trans-16, n-7) among Western populations may be associated with reduced risk for T2D.	IC
(7)	2020	SR / MA	SFA replacement	There was little or no effect on diabetes diagnosis.	IIA
(29)	2019	SR	MUFA, PUFA and omega-6 PUFAs	15 studies included. The increase of PUFA and total omega-6 PUFA intake in place of carbohydrate was associated with a lower risk of T2D (RR: 0.90; 95% CI: 0.82-0.98; per 5% of TEI) and 0.99 (95% CI: 0.97-1.00 per increment of 1 g/d), respectively. Increasing MUFA in place of carbohydrate was associated with a higher risk of type 2 diabetes (RR 1.10, 95% CI: 1.01-1.19 per 5% of TEI).	IA (PUFA) IIIA (MUFA)
(30)	2019	SR / MA	Omega-3 and omega-6 PUFAs	83 RCTs included. Long chain omega-3 had little or no effect on diagnosis of diabetes (RR: 1.00, 95% CI: 0.85-1.17). Effects of alpha-linolenic acid, omega-6, and total PUFA on diagnosis of diabetes were unclear as the evidence was of very low quality. No evidence was found that the omega-3/omega-6 ratio is important for diabetes.	IIB
(32)	2020	UR	Olive oil	Results of the review suggest that high intake of olive oil significantly reduced the risk of T2D.	IA
(5)	2017	SR / MA	Butter	11 studies included. Butter consumption was inversely associated with incidence of diabetes (RR: 0.96; 95% CI: 0.93-0.99).	IB
Obesity					
(33)	2020	SR	Fat, all types	37 RCTs included. The effect of eating less fat (compared with higher fat intake) is a mean body weight reduction of 1.4 kg (95% CI: -1.7, -1.1). The size of the effect on weight does not alter over time and is mirrored by reductions in BMI (-0.5 kg/m^2; 95% CI: -0.6, -0.3), waist (-0.5 cm; 95% CI: -0.7, -0.2), and percentage body fat (-0.3%; 95% CI: -0.6, 0.00).	IA
(7)	2020	SR / MA	SFA replacement	There was small reductions in weight and BMI.	IA
(10)	2018	SR / MA	PUFA	Increasing PUFA probably has little or no effect on obesity (body weight MD 0.76 kg, 95% CI: 0.34, 1.19).	IIA
(14)	2018	SR / MA	Omega-6	Increasing omega-6 fats probably has little or no effect on obesity (BMI -0.20 kg/m^2, 95% CI: -0.56, 0.16).	IIB
(39)	2020	SR / MA	Coconut oil	No effect on weight (-0.23 kg; -3.98, 3.53), BMI (-0.04 kg/m^2; -1.38, 1.29) or waist (1.33 cm; 95% CI: -3.34, 6.00)	IIA
(40)	2020	SR / MA	Coconut oil	8 studies included. Coconut oil intake did not significantly affect weight (-0.23 kg; 95% CI: -0.82, 0.36) or waist (-0.63; 95% CI: -2.44, 1.19) as compared with nontropical vegetable oils.	IIA

Table 42: direction of the associations between oils and fatty foods and health outcomes

	CVD mortality	CVD events	Stroke	Diabetes	Cancer	Obesity
Type of fat						
Total	↔	↔			↔ or ↑	
SFA	↔ or ↑	↑		↓	↔ or ↑	↑
MUFA	↔		↓	↑	↓	
PUFA	↔ or ↓	↔		↔ or ↓	↓ or ↑	↔
TFA	↑	↑	↔			
Double bound position						
Omega-3	↓	↔ or ↓		↔ or ↓ or ↑		
Omega-6		↔		↔ or ↓		↔
Specific fats						
Vegetable oil					↔	
Olive oil					↔ or ↓	
Palm oil		↑				
Coconut oil						↔
Butter		↔			↔ or ↑	

↔: no association; ↑: increased risk; ↓: decreased risk

2.13.6 References

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3 Link between foods and environmental impacts

Authors: M. Alig, S. Mäder, F. Schaich Reviewers: S. Frei, C. Sangin, M. Meyer and E. Infanger

3.1 Introduction

Dietary patterns and the associated foods not only have an impact on the health of people, but they also have a decisive influence on the health of our planet (1). The environmental impact caused by food have increasingly become the focus of attention in recent years, and it has been recognized that our current global diet is not compatible with living within the planetary carrying capacity (1, 2).

Today, five of nine planetary boundaries (3) are transgressed (4, 5). The safe operating space is exceeded for novel entities, biosphere integrity, biogeochemical flows, land-system change and climate change. Except of novel entities, all those boundaries are directly related to food production - as well as in terms of being influenced by and influencing food production. The global food system causes about one third of anthropogenic greenhouse gas emissions worldwide (6; 7). Agriculture is estimated to use 40 % of Earth's ice-free land, account for 70 % of freshwater withdrawals, and contribute 32 % of global terrestrial acidification and 78 % of eutrophication. Expansion of agricultural land is the largest driver of deforestation, accounting for 80% of deforestation worldwide. This exploitation of natural resources and pollution have a direct impact on biodiversity on land and in water, with food production threatening >70% of birds and mammals that are listed as threatened with extinction by the International Union for Conservation of Nature. Further, approximately 34% of the world's marine fish stocks are overfished and 60% are fully exploited (8).

The situation in Switzerland is similar. The Swiss limits are crossed for five out of nine planetary boundaries (9), with a worse situation compared to the global one for nitrogen losses and land cover. The provision of food accounts for almost 30 % of the total environmental impact caused by Swiss consumption and is thus the most important area of final consumption, ahead of housing and mobility (10). With a consistent focus on environmental protection and resource conservation, the environmental impact of the Swiss population's diet could be more than halved (19). Therefore, the current Swiss dietary recommendations already contain references to sustainable nutrition. Further recommendations regarding a sustainable diet are summarized through the FoodPrints [1]. Adherence to the current dietary recommendations compared to the actual Swiss consumption would already lead to a 49% reduction of environmental impact (19).

The environmental impact generated by individual foodstuffs varies considerably. In general, animal-based foods have a significantly higher environmental impact than plant-based foods. Within the different animal products, ruminant meats (mainly beef) have a much larger impact compared to pig and poultry meats (11). Even within the same food products the environmental impact can vary greatly, depending on environmental conditions and production methods. According to Jungbluth et al. (10) the environmental impact can vary 50-fold among producers of the same product.

The differences in the environmental impact of food products implicate that different diets also have different impact on the environment (12). A change in diet can have a big impact on the resulting environmental impact (13; 14).

If the goal of living within the planetary boundaries should be reached, it is inevitable to reduce the environmental impact of food consumption. There are different possibilities to do so: First, production methods can be improved in order to produce the same kind and amount of food with less impact. Second, by reducing food losses, the amount of food production needed to meet food demand can be reduced. Reducing the amount of food produced will reduce the associated environmental impact. However, these two measures will not be sufficient to reduce the environmental impact of food production to a planetary compatible level (1, 2). A third measure is necessary: Changing the way we

[1] https://www.sge-ssn.ch/ich-und-du/essen-und-trinken/ausgewogen/foodprints/

eat, i.e., our diet. Switching from a meat-based diet to a vegetarian (no meat) diet, e.g., can reduce the environmental impact of nutrition by 35 % (13).

It is therefore important to also consider environmental aspects when developing nutritional recommendations. This chapter shows the environmental impact of different food items in the Swiss food pyramid and thus establishes the basis for modelling a healthy and sustainable diet for the Swiss population.

3.2 Methodology

The environmental impact of 44 important food items / food ingredients in the Swiss food pyramid are investigated by life cycle assessment (LCA). The influence of or the impacts on the economic or social dimension (e.g., prices) of sustainability are not considered. The food items investigated are shown in the supplementary information. The following subchapter describes the methodology used and the underlying assumptions.

3.2.1 Life cycle assessment

The methodology of life cycle assessment is defined in ISO standards 14040/44 and is divided into the four steps (1) goal and scope definition, (2) inventory analysis, (3) impact assessment and (4) interpretation (Figure 1).

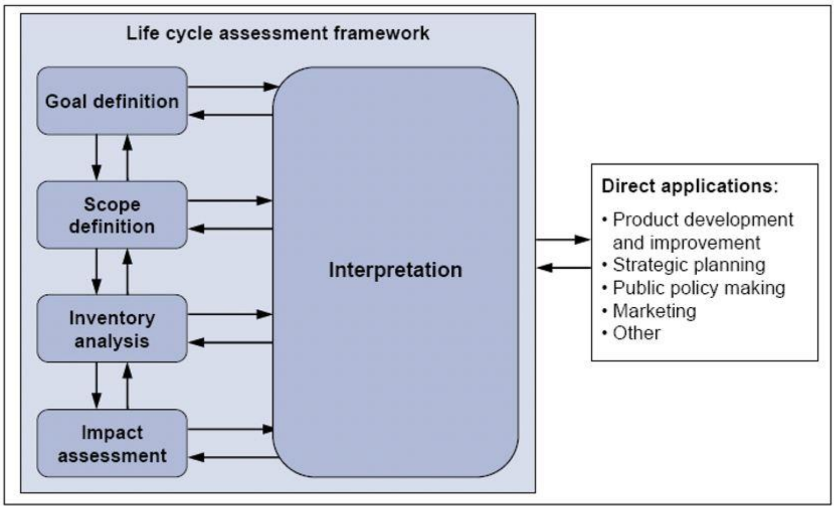

Figure 1: The four phases of a LCA (ISO 14040:2006).

The definition of the goal and the scope of the study is decisive for the result of a study. The benefits and function of the product under investigation and its life cycle must be defined. Assumptions, limitations, and the boundaries of the investigation are specified. Furthermore, the so-called functional unit (FU) is defined, i.e., the product-specific quantity to which the environmental impact is subsequently related. Examples are 1 kg of bread, 1 kWh of electrical energy, 1 ha of agricultural land, etc. The FU has to enable a fair comparison between the considered products and be representative of the studied system.

The life cycle inventory makes quantitative statements about the consumption of raw materials and the emission of pollutants into the environment along the entire life cycle. The compilation of the life cycle inventory is supported by various databases such as ecoinvent[2], World Food Life Cycle Database[3], or the UVEK database developed by the Swiss Administration.

The impact assessment assigns the results of the life cycle inventory to different impact categories according to scientifically based criteria. An impact category summarizes the environmental impact of

[2] https://ecoinvent.org/
[3] https://quantis-intl.com/metrics/databases/wfldb-food/

the individual substances on an environmental topic such as global warming, nutrient enrichment or summer smog. The importance of the individual emissions for the respective impact category is determined by means of impact factors. These factors convert all classified flows for an impact into common units for comparison. For example, nitrous oxide contributes 298 times more to climate change than CO_2.

In the evaluation, all preceding steps are critically reviewed and the parameters essential for the result are identified. The consistency and completeness of the analysis is checked, and a sensitivity analysis provides information on the uncertainty of the results. The indicators such as eco-point (UBP) of different alternative products or processes can be compared. Recommendations are derived according to the set targets or an ecological performance is proven (e.g. reduction of greenhouse gas emissions).

3.2.2 System boundaries

For the analysis of the different food items, the life cycle stages 'cradle to shop' were considered. This includes agricultural production, food processing, food packaging, transports to the supermarket and the supermarket itself. Not included is home transport, consumption, and end-of-life of the products. The disposal of the packaging, however, is taken into account.

The food items assessed are modelled with mixes of corresponding food products (see supplementary information). The inventories used represent average or typical production of the corresponding food products.

No differentiation is made for primary production systems such as organic or other production systems according to specific production standards. Conventional production is used as default and the situation for the supply in Switzerland is considered. Import mixes are only used if already available, no new mixes are calculated. For products produced in Switzerland, the impact of Swiss primary production is evaluated. Foreign products are investigated with the data easily available (global mix or country specific data without further research on real import mixes). Furthermore, no distinction is made between different types of food processing (e.g. food UHT *vs.* pasteurized milk).

Transports until shop are considered. For products produced abroad, generic transport chains for the transport to Switzerland were developed considering the most important countries of origin, typical transport routes and means of transports (ship for sea transports and lorry for road transports). For all products, transports within Switzerland were modelled with 100 km transport distance from border to the distribution centre and 50 km transport from the distribution centre to the shop. It was assumed that the products are transported to 30 % by train and 70 % by lorry.

Food waste from field to fork (agriculture, processing, and retail) is taken into account according to the life cycle inventories used (processing) and complemented with information from Beretta (15) for losses in agriculture and retail.

3.2.3 Methods & Assumptions for life cycle stages

For the modelling of the agricultural production and processing a life cycle inventory (LCI) was assigned to each food product (see supplementary information). All inputs used for the production of the unprocessed food product at farm are allocated to the stage of agricultural production. Any inputs related to the further processing such as drying, or cooking are allocated to the stage of processing.

The food packaging of each product is modelled according to data from the database Agribalyse. The database provides average inputs for the packaging of each food product.

The modelling of the transport of the food products to the supermarket relies on data from the Agricultural Report 2021 of the Federal Office for Agriculture[4] and the Swiss-Impex Database of the Federal Office for Customs and Border Security[5]. To determine the share of domestic production the average self-sufficiency rate of Switzerland of the of the years 2015-2019 as published in the Agricultural Report

[4] https://www.agrarbericht.ch/de
[5] https://www.gate.ezv.admin.ch/swissimpex/

2021 were considered. For product groups where no data was available (mostly products not grown in Switzerland) own assumptions were made. To determine the origin of the imported products, all countries which in total imported more than 80 % of the respective good in the years 2017-2021 or the five biggest importing countries were considered. The share of each origin was then scaled to the share of foreign production of each product. For each origin an average transport distance was calculated, which is assumed to be transported by an average Swiss lorry fleet. For countries oversees, it was assumed that goods are transported by container ship. It is possible that some of the products may be transported by airplane. However due to the lack of information on air transport, it was neglected in this study. The country origins of the products were only considered for the modelling of the transport but not for the production and processing due to a lack of country specific data.

The stage at the supermarket considers the electricity and water needed for the running of a supermarket as well as the electricity needed for the cooling of chilled products.

3.2.4 Reference unit

The environmental impact is expressed per weight (100 g food item) and per nutritional value (kcal).

3.2.5 Database

As a first choice, the environmental data on the production of the food items is taken from the World Food Life Cycle Database (WFLDB), linked to the background database UVEK DQRv2_2018. If no data is available in WFLDB, additional data from Agribalyse and Ecoinvent v3.8 are used.

3.2.6 Indicators

The ecological scarcity method according to (16) is used as impact assessment method. The key metrics of this method are eco-factors, which measure the environmental damage in eco-points (UBP) per unit of quantity. The impact assessment of life cycle inventories is based on the distance-to-target principle. To derive an eco-factor, the current situation is set in relation to the tolerated target quantity, which is defined based on Swiss legislation. The ecological scarcity method, also called the UBP- method, was first published in 1990. For this assessment, this fourth edition of the eco-factors was used, including eco-factors for the use of marine fish resources. Figure 2 shows the basic scheme of the methodology including the environmental dimensions considered.

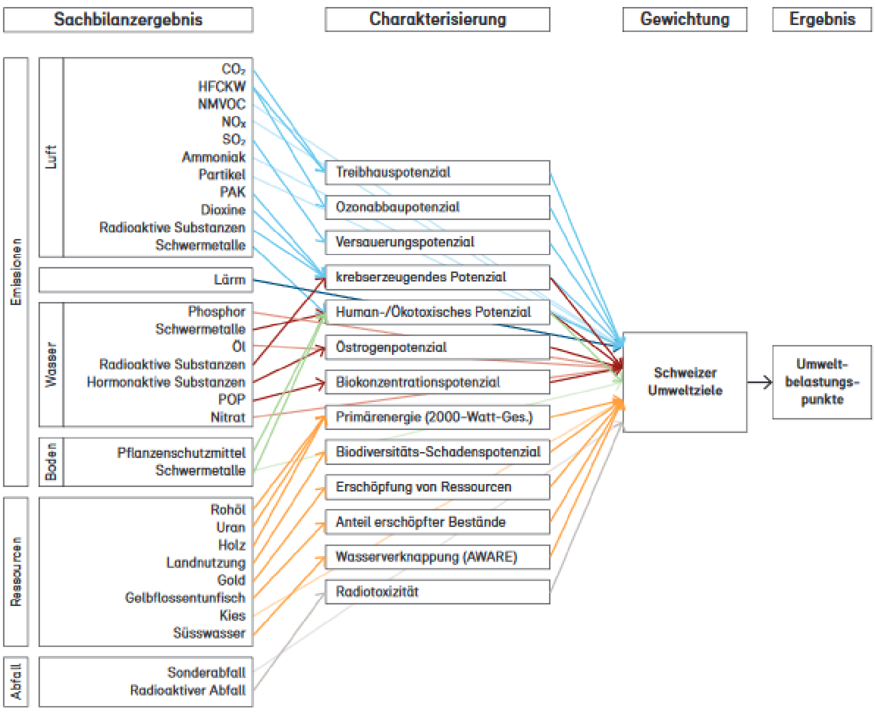

Figure 2: Basic scheme of the ecological scarcity method (eco-factors Switzerland 2021) with the steps life cycle inventory, characterization and weighting (15).

As a sensitivity analysis, additional to the method of ecological scarcity, two other environmental indicators are assessed: ReCiPe Endpoint (17) and Global Warming Potential according to IPCC (18).

ReCiPe is the successor of the methods Eco-indicator 99 and CML-IA. The purpose at the start of the development was to integrate the ‘problem-oriented approach’ of CML-IA and the ‘damage-oriented approach’ of Eco-indicator 99. ReCiPe offers a broad set of midpoint impact categories and uses impact mechanisms that have global scope, where possible. Unlike the method of ecological scarcity, it does not take into account Swiss legislation.

Global Warming Potential assesses the potential impact of greenhouse gas emissions on climate change. The greenhouse gases considered are CO_2, CH_4, N_2O, chlorinated and fluorinated hydrocarbons, SF6 and NF3. In this study, the radiative forcing over a time horizon of 100 years was considered (18).

3.3 Results

The top chart of **Figures 3 to 5** as well as **Table 43** show the environmental impact in eco-points (UBP) per 100 g of edible portion for the food items assessed by agricultural production, processing, packaging, transport and supermarket. The additional impact methods used are shown in the supplementary material.

The food items with the highest environmental impact per weight are coffee, red meat, fish and shellfish, nuts and seeds, chocolate and tea, followed by vegetable oils and poultry.

For coffee, it is especially freeze-dried coffee which contributes to this high impact per 100 g. The impact of ground coffee is about 50% lower than the impact of freeze-dried coffee. This is due to the weight losses which occur during freeze drying, meaning that nearly twice as many green beans are needed per kilogram of instant coffee as for one kilogram of ground coffee. Additionally, freeze drying is a very energy intensive process.

For red meat, nearly 80% of the impact is caused by beef and veal, 20% by pork meat. The high impact of beef meat is mainly caused by methane emissions during enteric fermentation, as well as emissions caused by feed production. For pork meat, the main contribution comes from feed production.

For shellfish, especially the shrimps cause a high environmental impact per 100 g. This is due to the feed production for the farming of the shrimps. Omega-3 rich fish has an even higher environmental impact compared to shellfish, due to the depletion of natural fish stocks. Depending on the fish species and stock, the consideration of overfishing can result in very high environmental impacts. Omega-3 poor fish is more frequently farmed leading to a lower impact compared to omega-3 rich fish.

For nuts and seeds, the highest contributions to the environmental impact stem from pesticide application in hazelnut production as well as land use change caused by and direct emissions during cashew growing. Also, for chocolate, land use change caused by cocoa cultivation contributes most the high environmental impact. For tea, pesticides emissions are the most important contribution.

The food items with the lowest environmental impact per weight are (in ascending order) tap and mineral water, milk alternatives, salad, milk, potatoes and other tubers, soft drinks, and vegetables. For vegetables, the range within this group is quite wide. Especially vegetables partly or fully grown in heated greenhouses such as mushrooms or tomatoes exhibit a high impact.

The lowest chart of **Figures 3 to 5** shows the share of the different life cycle stages in the environmental impact of the food items assessed. In general, the agricultural stages contribute by far most to the environmental impact per weight. For some food items, such as yoghurt, vegetable and animal fats, dried fruits, meat substitutes and bread the processing is also important. This is mostly linked to a high energy consumption during processing. Please note that for wild caught fish, no agricultural impacts were considered. All impacts from fishing were attributed to the processing stage, including the impacts of overfishing.

Packaging only plays a role for mineral water, which is linked to the low impact of the mineral water itself. Also, the transports are important rather for food items with a low impact through agricultural production and processing, such as milk alternatives, mineral water and salad. For avocado, the transports are important as this fruit is to 100% imported. Also, for fruit juices, which are to a great share imported, the transports play a role.

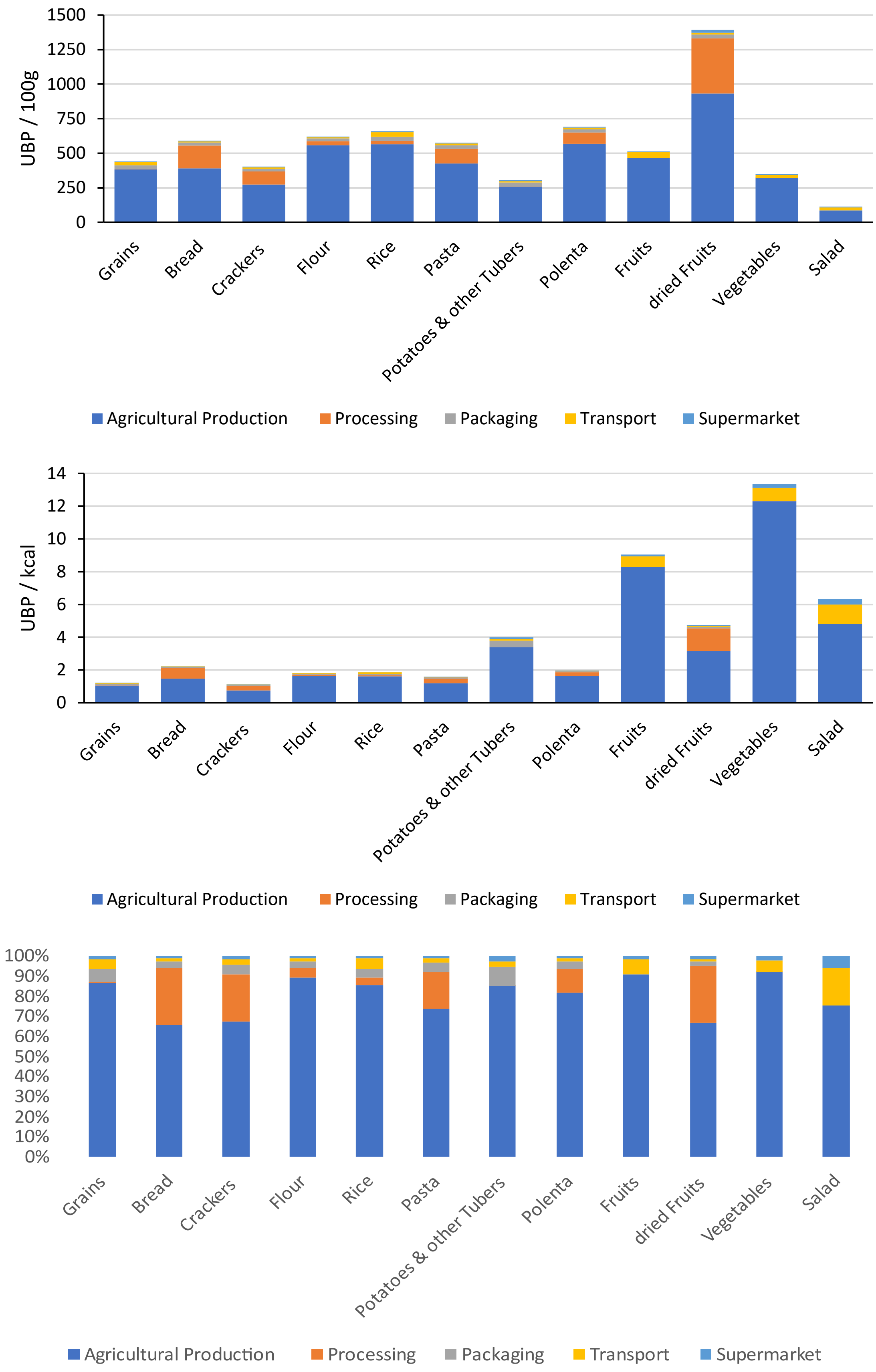

Figure 3: Environmental impact of cereals, starch-containing foods, fruits, and vegetables according to the ecological scarcity method per 100 g of edible food, per kcal of edible food and share of life cycle stages.

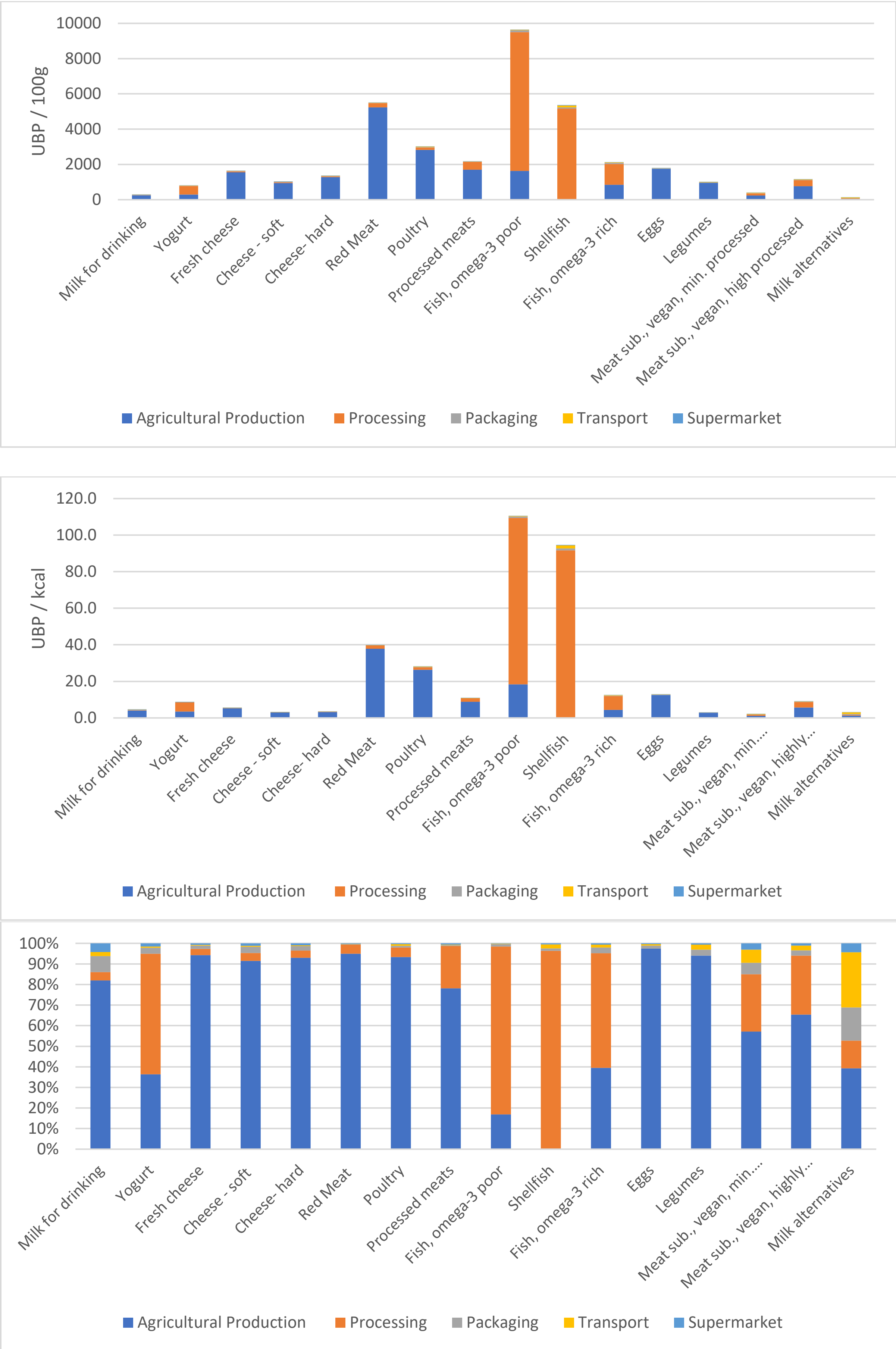

Figure 4: Environmental impact of dairy products, meat, fish, eggs, and other proteins according to the

ecological scarcity method per 100g of edible food, per kcal of edible food and share of life cycle stages.

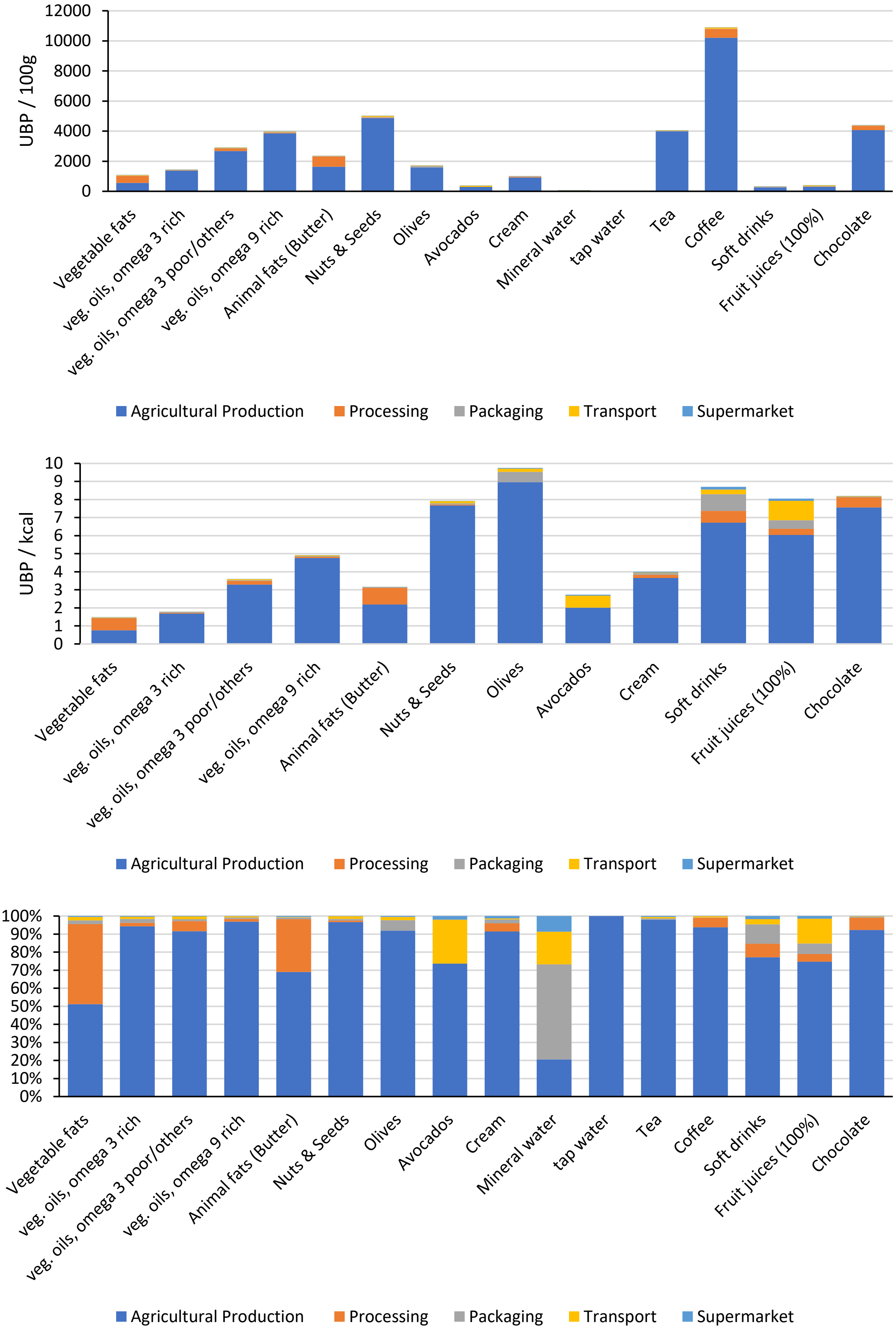

Figure 5: Environmental impact of oils, fats, sweets and beverages according to the ecological scarcity

method per 100 g of edible food, per kcal of edible food and share of life cycle stages.

Storage in supermarket has in general a minor role, with a maximum contribution of 11% for mineral water (see **Table 44**). The high share of the supermarket in the environmental impact of mineral water is mainly due to the low impact of the production of the mineral water itself. In absolute numbers, the contribution of the supermarket to the total environmental impact of mineral water is in the same range as for the other food items stored at ambient temperature. For food items that are kept refrigerated, the supermarket's contribution is generally slightly higher, however, the preceding stages of the life cycle are more important.

If you look at the environmental impact per kcal, the picture changes (see middle chart of **Figures 3 to 5** and **Table 45**). The animal-based food items (shellfish, red meat, poultry, fish, and processed meats) now show clearly higher environmental impacts than the other food items. This is linked to the fact that the energy content of these food items is lower compared to the food items which also showed a high impact when expressed per 100 g of food item (nuts and seeds, chocolate). As no-calorie beverages (e.g., water or tea) do not contain any digestible energy, they are not considered when expressing the environmental impact of food items per kcal.

Table 46 shows an overview of the environmental impacts of the different food products and a short summary of the most important contributors to their environmental impact.

Table 43: Environmental impact in UBP per 100 g of edible food

Food items	Agricultural Production	Processing	Packaging	Transport	Supermarket	Total
Dairy products, meat, fish & plant-based alternatives						
Milk for drinking	244.92	12.03	23.34	5.68	12.67	298.63
Yoghurt	296.59	477.04	23.58	5.08	12.67	814.96
Fresh cheese	1553.04	48.28	27.86	5.08	12.67	1646.93
Cheese - soft	947.61	39.70	30.35	5.08	12.67	1035.42
Cheese- hard	1274.22	47.54	30.35	5.08	12.67	1369.86
Red meat - beef, veal, lamb, pork, horse	5236.79	243.11	16.45	6.97	12.67	5516.00
Poultry	2821.48	138.98	24.81	24.56	12.67	3022.49
Processed meats	1704.97	448.47	10.05	6.47	12.67	2182.63
Fish, omega-3 poor	1631.52	7864.55	109.41	28.88	12.67	9647.03
Shellfish	0.00	5165.93	66.53	105.16	25.99	5363.62
Fish, omega-3 rich	841.69	1187.80	58.87	30.14	12.67	2131.17
Eggs	1755.96	0.00	27.40	12.42	6.71	1802.49
Legumes	956.33	0.00	30.35	24.86	5.90	1017.44
Meat substitutes, vegan, minimally processed	237.62	115.34	23.58	26.38	12.67	415.59
Meat substitutes, vegan, highly processed	766.54	335.06	30.35	27.57	12.67	1172.20
Milk alternatives	53.23	18.15	22.01	36.23	5.90	135.52
Cereals & starchy foods						
Grains	382.70	1.50	29.22	21.71	5.90	441.03

Food items	Agricultural Production	Processing	Packaging	Transport	Supermarket	Total
Bread	390.11	166.08	20.89	7.70	5.90	590.68
Crackers	272.82	94.43	19.34	11.36	5.90	403.84
Flour	557.29	28.92	20.89	8.03	5.90	621.04
Rice	564.25	24.74	30.35	33.41	5.90	658.65
Pasta	424.86	106.17	26.96	12.11	5.90	576.01
Potatoes & other tubers	258.71	0.09	28.86	9.24	7.08	303.98
Polenta	568.53	80.97	23.58	12.13	5.90	691.11
Oils & fats						
Vegetable fats	551.98	477.79	22.93	19.64	5.90	1078.24
Vegetable oils, omega 3 rich	1366.39	27.39	32.33	16.81	5.90	1448.82
Vegetable oils, omega 3 poor/ other oils	2672.20	163.61	32.33	43.83	5.90	2917.86
Vegetable oils, omega 9 rich	3853.94	57.64	32.33	26.13	5.90	3975.94
Animal fats (butter)	1631.54	690.09	22.93	5.08	12.67	2362.31
Nuts & seeds	4863.36	39.31	45.39	73.72	7.68	5029.45
Olives	1577.69	0.00	100.78	30.87	7.56	1716.90
Avocados	289.05	0.00	0.00	95.65	7.97	392.68
Cream	921.97	45.27	22.93	5.68	12.67	1008.52
Fruits, vegetables, beverages						
Fruits	466.76	0.00	0.00	39.75	7.09	513.60
Dried fruits	931.97	399.52	28.48	12.79	19.67	1392.43
Vegetables	321.81	0.25	0.00	20.42	6.32	348.80

Food items	Agricultural Production	Processing	Packaging	Transport	Supermarket	Total
Salad	86.51	0.00	0.00	21.33	6.28	114.11
Mineral water	13.91	0.00	35.61	12.18	5.90	67.61
Tap water	0.04	0.00	0.00	0.00	0.00	0.04
Tea	3986.80	0.00	30.35	33.72	19.67	4070.54
Coffee	10215.51	578.12	24.11	73.34	5.90	10896.99
Soft drinks	255.45	24.41	35.61	9.41	5.90	330.79
Fruit juices (100%)	296.93	16.87	23.34	54.56	5.90	397.60
Chocolate	4062.07	298.43	24.11	12.18	5.90	4402.70

Table 44: Share of life cycle stages in total environmental impact according to the method of ecological scarcity per 100g of edible food

Food items	Agricultural production	Processing	Packaging	Transport	Supermarket
Dairy products, meat, fish & plant-based alternatives					
Milk for drinking	82%	4%	8%	2%	4%
Yoghurt	36%	59%	3%	1%	2%
Fresh cheese	94%	3%	2%	0%	1%
Cheese - soft	92%	4%	3%	0%	1%
Cheese- hard	93%	3%	2%	0%	1%
Red meat - beef, veal, lamb, pork, horse	95%	4%	0%	0%	0%
Poultry	93%	5%	1%	1%	0%
Processed meats	78%	21%	0%	0%	1%
Fish, omega-3 poor	17%	82%	1%	0%	0%
Shellfish	0%	96%	1%	2%	0%
Fish, omega-3 rich	39%	56%	3%	1%	1%
Eggs	97%	0%	2%	1%	0%
Legumes	94%	0%	3%	2%	1%
Meat substitutes, vegan, minimally processed	57%	28%	6%	6%	3%
Meat substitutes, vegan, highly processed	65%	29%	3%	2%	1%
Milk alternatives	39%	13%	16%	27%	4%
Cereals & starchy foods					
Grains	87%	0%	7%	5%	1%

Food items	Agricultural production	Processing	Packaging	Transport	Supermarket
Bread	66%	28%	4%	1%	1%
Crackers	68%	23%	5%	3%	1%
Flour	90%	5%	3%	1%	1%
Rice	86%	4%	5%	5%	1%
Pasta	74%	18%	5%	2%	1%
Potatoes & other tubers	85%	0%	9%	3%	2%
Polenta	82%	12%	3%	2%	1%
Oils & fats					
Vegetable fats	51%	44%	2%	2%	1%
Vegetable oils, omega 3 rich	94%	2%	2%	1%	0%
Vegetable oils, omega 3 poor/ other oils	92%	6%	1%	2%	0%
Vegetable oils, omega 9 rich	97%	1%	1%	1%	0%
Animal fats (butter)	69%	29%	1%	0%	1%
Nuts & seeds	97%	1%	1%	1%	0%
Olives	92%	0%	6%	2%	0%
Avocados	74%	0%	0%	24%	2%
Cream	91%	4%	2%	1%	1%
Fruits, vegetables, beverages					
Fruits	91%	0%	0%	8%	1%
Dried fruits	67%	29%	2%	1%	1%
Vegetables	92%	0%	0%	6%	2%

Food items	Agricultural production	Processing	Packaging	Transport	Supermarket
Salad	76%	0%	0%	19%	6%
Mineral water	21%	0%	53%	18%	9%
Tap water	100%	0%	0%	0%	0%
Tea	98%	0%	1%	1%	0%
Coffee	94%	5%	0%	1%	0%
Soft drinks	77%	7%	11%	3%	2%
Fruit juices (100%)	75%	4%	6%	14%	1%
Chocolate	92%	7%	1%	0%	0%

Table 45: Environmental impact in UBP per kcal of the edible food

Food items WP4 (Sustainability) - only edible parts	Agricultural Production	Processing	Packaging	Transport	Supermarket	Total
Dairy products, meat, fish & plant-based alternatives						
Milk for drinking	3.950	0.194	0.376	0.092	0.204	4.817
Yoghurt	3.487	4.927	0.269	0.057	0.138	8.878
Fresh cheese	5.246	0.163	0.094	0.017	0.042	5.562
Cheese - soft	2.916	0.122	0.093	0.016	0.039	3.186
Cheese- hard	3.210	0.120	0.076	0.013	0.032	3.451
Red meat - beef, veal, lamb, pork, horse	37.864	1.739	0.121	0.051	0.098	39.872
Poultry	26.369	1.299	0.232	0.230	0.118	28.248
Processed meats	8.855	1.939	0.049	0.033	0.081	10.957
Fish, omega-3 poor	18.415	91.0241	0.718	0.301	0.121	110.578
Shellfish	0.000	91.625	1.065	1.654	0.371	94.715
Fish, omega-3 rich	4.417	7.558	0.301	0.173	0.071	12.519
Eggs	12.543	0.000	0.196	0.089	0.048	12.875
Legumes	2.846	0.000	0.090	0.074	0.018	3.028
Meat substitutes, vegan, minimally processed	1.172	0.648	0.147	0.164	0.073	2.204
Meat substitutes, vegan, highly processed	5.667	3.008	0.239	0.213	0.075	9.202
Milk alternatives	1.262	0.420	0.519	0.849	0.139	3.189
Cereals & starchy foods						
Grains	1.054	0.004	0.080	0.059	0.016	1.213
Bread	1.478	0.629	0.079	0.029	0.022	2.237

Food items WP4 (Sustainability) - only edible parts	Agricultural Production	Processing	Packaging	Transport	Supermarket	Total
Crackers	0.749	0.276	0.052	0.030	0.016	1.122
Flour	1.625	0.084	0.061	0.023	0.017	1.811
Rice	1.607	0.070	0.086	0.095	0.017	1.875
Pasta	1.182	0.296	0.075	0.034	0.016	1.604
Potatoes & other tubers	3.402	0.001	0.379	0.121	0.093	3.997
Polenta	1.624	0.231	0.067	0.035	0.017	1.975
Oils & fats						
Vegetable fats	0.762	0.660	0.032	0.027	0.008	1.489
Vegetable oils, omega 3 rich	1.687	0.034	0.040	0.021	0.007	1.789
Vegetable oils, omega 3 poor/ other oils	3.293	0.201	0.040	0.053	0.007	3.593
Vegetable oils, omega 9 rich	4.758	0.071	0.040	0.032	0.007	4.909
Animal fats (butter)	2.190	0.926	0.031	0.007	0.017	3.171
Nuts & seeds	7.670	0.057	0.071	0.117	0.012	7.926
Olives	8.964	0.000	0.573	0.175	0.043	9.755
Avocados	2.007	0.000	0.000	0.664	0.055	2.727
Cream	3.659	0.180	0.091	0.023	0.050	4.002
Fruits, vegetables, beverages						
Fruits	8.301	0.000	0.000	0.631	0.119	9.051
Dried fruits	3.162	1.375	0.097	0.043	0.067	4.744
Vegetables	12.305	0.006	0.000	0.804	0.237	13.352
Salad	4.806	0.000	0.000	1.185	0.349	6.340

Food items WP4 (Sustainability) - only edible parts	Agricultural Production	Processing	Packaging	Transport	Supermarket	Total
Soft drinks	6.722	0.642	0.937	0.248	0.155	8.705
Fruit juices (100%)	6.038	0.343	0.476	1.074	0.120	8.050
Chocolate	7.564	0.556	0.045	0.023	0.011	8.199

Table 46: Summary of results of impact per 100 g of product.

Food items	**Summary of impact per 100 g**
Dairy products, meat, fish & plant-based alternatives	The impact of dairy and beef & veal meat is rather high. Especially beef exhibits a high environmental impact. It is mainly caused by methane emissions during enteric fermentation, as well as emissions caused by feed production.
Milk for drinking	The impact of milk is mainly caused by methane emissions during enteric fermentation, as well as emissions caused by feed production.
Yoghurt	Yoghurt has a particularly high impact in processing if additional ingredients (such as chocolate), which have a high environmental impact, are added during this stage.
Fresh cheese	Fresh cheese has a higher environmental impact than soft and hard cheese due to the different modelling approach of the underlying databases. For fresh cheese, a higher use of grassland and more nitrogen and greenhouse gas emissions are assumed than for soft and hard cheese. However, this is rather a modelling effect. Related to milk input, it can be assumed that fresh cheese has lower impacts than soft and especially hard cheese.
Cheese - soft	The impact of soft cheese is lower than the impact of hard cheese as less milk is required for the production.
Cheese- hard	The impact of hard cheese is higher than the impact of soft cheese as more milk is required for the production.
Red meat - beef, veal, pork	For red meat, nearly 80 % of the impact is caused by beef and veal, 20 % by pork meat. For pork meat, the main impact comes from feed production.
Poultry	The main impact of poultry comes from feed production.
Processed meats	The impact of processed meat is higher for beef and veal meat compared to pork and poultry. As processed meat has a high share of pork, the impact is lower compared to red meat. Higher impacts emerge from higher electricity use for processing.
Fish, omega-3 poor	The impact of fish varies depending on the production systems. While the main impact of farmed fish stems from the feed production, the main impact of wild caught fish arises from the depletion of biotic resources. The impacts from wild caught fish tend to be higher than those of farmed fish.
Shellfish	Shellfish, especially the shrimps cause a high environmental impact. This is due to the feed production for the farming of the shrimps.

Food items	Summary of impact per 100 g
Fish, omega-3 rich	The impact of fish varies depending on the production systems. While the main impact of farmed fish stems from the feed production, the main impact of wild caught fish arises from the depletion of biotic resources. The impacts from wild caught fish tend to be higher than those of farmed fish.
Eggs	The impact mainly comes for feed production.
Legumes	The range within the group varies depending on the type of legume. Lentils have a high environmental impact due to the application of pesticides, for the chickpea production high impacts come from direct emissions from composting and soybeans have a high impact from land use change.
Meat substitutes, vegan, minimally processed	The impact of meat substituted varies depending on the type of product. Tofu has a lower impact than falafel due to the high impacts of chickpeas and olive oil. However, this depends on the type of raw materials used for tofu and falafel.
Meat substitutes, vegan, highly processed	The majority of impacts stems from pea protein. Pea protein has a high impact from the use of fertilizer and land use change.
Milk alternatives	Milk alternatives have a very small environmental impact due to the very high water content of the products.
Cereals & starchy foods	The impact of cereals and starchy foods is rather low. It is mainly caused by fertilization during cultivation and for processed foods by the energy use during processing.
Grains	The main impacts of grains arise from nitrate fertilization and to a smaller degree from the application of pesticides.
Bread	The environmental impact of bread is mainly caused by the fertilization of the wheat grains. Around 25% of the impact is caused by the electricity needed for baking.
Crackers	The environmental impact of crackers is mainly caused by the fertilization of the wheat grains. Around 25% of the impact is caused by the electricity needed for baking. Crackers have a lower environmental impact than bread, which can be explained by the different modelling approach of the underlying databases.
Flour	The environmental impact of flour is mainly caused by the fertilization of the wheat grains.
Rice	Rice production leads to direct CO2 and methane emissions due to the flooding of rice fields leading to an anaerobic production atmosphere. Additionally environmental impacts stem from the use of pesticides and irrigation.

Food items	Summary of impact per 100 g
Pasta	The environmental impact of pasta containing egg is slightly higher compared to egg-free pasta, however the higher impact of the egg can be partially compensated by the use of wheat flour instead of durum wheat semolina, which has a lower environmental impact.
Potatoes & other tubers	The environmental impact is mainly caused by the application of pesticides.
Polenta	The main environmental impacts stems from the application of pesticides and fertilizer.
Oils & fats	The impact of oils and fats is rather high per 100 g, but low per kcal. This is due to its high energy content. The impacts are mainly caused by fertilizer and pesticide use during cultivation. For some products, land use change plays also a role.
Vegetable fats	For margarine, the impacts arise about equally from greenhouse gas emissions (mainly from palm oil) and the use of pesticide and fertilizer (mainly from rapeseed oil).
Vegetable oils	The environmental impact of vegetable oils arises mainly from the application of pesticide and fertilizer. The level of the impact depends on the type and amount of pesticide/fertilizer used. For coconut oil the impact is dominated by land use change.
Animal fats (butter)	For butter, the impact is higher than for other dairy products as more milk is required for the butter product. However, parts of the impact are allocated to the co-products of the butter production.
Nuts & seeds	For nuts and seeds, the highest contributions to the environmental impact stem from pesticide application in hazelnut production as well as land use change caused by and direct emissions during cashew growing.
Olives	The application of pesticides with a high environmental impact contributes the most to the impact of olives.
Avocados	The environmental impact is relatively low and consists of impacts from greenhouse gas emissions, application of fertilizer and land use changes.
Cream	The impact of cream is small compared to other dairy products even though more milk is required for producing 1 kg of cream as cream is produced in co-production and hence only a small portion of the impact of milk is allocated to the cream production.
Fruits, vegetables, beverages	The impact of fruits, vegetables and beverages is low per 100 g, but rather high per kcal. This is due to its low energy content. The impacts exhibit a great range and depend on the way of cultivation. Especially cultivation in fossil heated greenhouses leads to high impacts.

Food items	Summary of impact per 100 g
Fruits	For fruits, the range within the group varies. Fruits that are fully grown in heated greenhouses such as strawberries and/or fruits that require high pesticide use have higher impacts.
Dried Fruits	The impact of dried fruits is higher than fresh fruits as more fruits for the production of 100 g are required and heat is required for the drying.
Vegetables	For vegetables, the range within this group is quite wide. Especially vegetables partly or fully grown in heated greenhouses such as mushrooms or tomatoes exhibit a high impact.
Salad	The impact of salad is lower compared to other vegetables as no heating is required.
Mineral water	Mineral water has a higher impact than tap water due to the production of CO_2 for sparkling water. The impacts are however very small.
Tap water	The only impact of tap water stems from the electricity used for water treatment and distribution, which is however very small.
Tea	For tea, pesticides emissions are the most important contribution.
Coffee	For coffee, the impact of ground coffee is about 50% lower than the impact of freeze-dried coffee. This is due to nearly 50% weight losses which occur during freeze drying. Additionally, freeze drying is a very energy intensive process.
Soft drinks	The main impacts stems from fruit juices used for the production of soft drinks.
Fruit juices (100%)	Although more fruits are needed to produce 100 g of juice, the impact is relatively low due to the dilution with water.
Chocolate	For chocolate, land use change caused by cocoa cultivation contributes most the high environmental impact.

The databases used to model the environmental impact are indicated in ***table 3 of the Annex****.*

3.4 Discussion

3.4.1 Data quality

The environmental impact of the food items analysed depends on the compilation of the respective food item and on the scale used (per 100 g vs. per kcal). Coffee has the highest impact per weight because this food item was calculated with 50% ground coffee and 50% instant coffee. If only ground coffee was considered, the impact would be halved. Still, it would be amongst the items with the highest impact, in the same range as red meat. The weighting of the different food products within one food item was partly based on consumption patterns (see chapter 5). It was also not possible to take into account all food products which belong to a certain food item. Nuts and seeds e.g. were modelled using hazel nuts, walnuts, cashew and almonds only. Other nuts and especially seeds like sunflower, pumpkin, etc. are not considered. For a better representativeness of the environmental impact of the different food item, consumption patterns would have to be considered for all food items. Consumption patterns however differ from recommendations. As the impact data created in this report will be used to model future recommendations and not current consumption, food items were mainly compiled without taking current consumption into account.

The calculations are based on existing, publicly available databases. To find data for all the foods under consideration, two different databases (WFLDB imported to UVEK-database and Agribalyse) had to be combined. The use of different databases could lead to different levels of environmental impact as a result of differences in background data and emissions' modelling on inventory level. Although the evaluation of the existing data did not show any irregularities in this effect, the use of a single, comprehensive database would nevertheless be welcomed. However, such a database would first have to be set up for Swiss food production. A fact to consider is that agricultural production is highly variable, so it is a huge effort to compile representative LCI-data. Therefore, in most inventories, a "typical" production is represented. Some inventories are built on a single case study, which cannot be judged as representative.

In the present evaluations, domestic production was used as far as possible for domestic products, and existing country mixes were used for imported products. However, these do not always reflect the actual countries of origin. This is particularly critical with regard to land use changes. These have a major influence on the environmental impact of products from tropical regions (e.g., chocolate, soy beans or palm oil) - here it would be important to consider the actual countries of origin of the raw materials (cocoa directly used and indirectly via other ingredients such as cocoa butter).

Another important issue is the use of pesticides. In the method of ecological scarcity, this can contribute a lot to the total environmental impact. Although the inventories used take pesticide use into account, they contain very generic and partly outdated data. An update of these data would improve the quality of the results.

Nevertheless, the results presented show a similar picture as other studies related to the environmental impact of food products. Red meat is among the food items with the highest environmental impact; water-based beverages and vegetables exhibit the lowest impacts.

3.4.2 Reference unit

As reference units, only 100 g of edible food and the 1 kcal energy content of edible foods are provided.

These reference units are easy to grasp and known to the consumer from nutritional information. However, they do not represent all nutritional dimensions of food. Food not only serves for energy intake, but also supplies us with proteins, vitamins, and other nutrients. These are not depicted in the two reference units chosen. Meat e.g., which is a main protein source and exhibits a high environmental impact per 100 g and per kcal, might look different when assessing the environmental impacts per amount of protein delivered.

Also, coffee has a high environmental impact per 100 g. However, coffee is consumed in very small amounts in the form of a cup of coffee. For a consumer, it does not make sense to compare the impact of 100 g of coffee to 100 g of meat, as those amounts are totally different portions when it comes to daily intake. This should be considered when communicating the results.

For the purpose of this report however, the two reference units suffice as further calculations and modelling will be conducted with the herewith provided data.

3.4.3 Factors not considered

Not considered were differences in production systems (e.g., organic production). Especially in the field of pesticide application organic products exhibit a significantly different impact than conventional products. As the main goal of the present study was to compare different food items, and not the share of organic products in different food items, this simplification was considered acceptable.

For transports it was assumed that all transports are made by ship or lorry. However, some food products (e.g. beef meet, some vegetables or tropical fruits) might be at least partly transported by air. Air transports significantly augment the environmental impact of a food product. Figure 6 shows the comparison of the environmental impact according to the ecological scarcity method of 1 kg asparagus produced in France and transported by lorry to Switzerland and 1 kg asparagus produced in Peru und flown to Switzerland. Although the impact of agricultural production is 40% lower for the asparagus produced in Peru, the impact of transports is 175 times higher, so that the overall environmental impact of the asparagus produced in Peru is four times higher than the one produced in France.

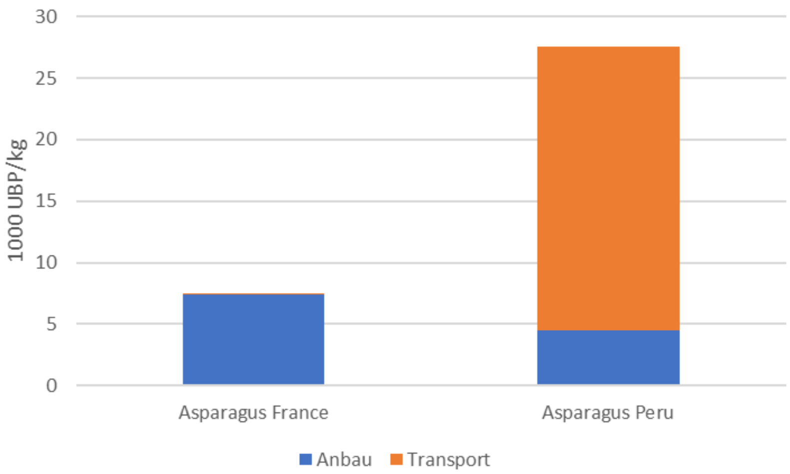

Figure 6: Comparison of environmental impact according to the method of ecological scarcity of 1 kg asparagus produced in France and transported by lorry to Switzerland and 1 kg asparagus produced in Peru and flown to Switzerland

However, as the impact data in this report will be used to model future recommendations, it is advisable to not mix the impact of the actual food item and eventual air transports. Air transport is not unavoidably linked to a specific food item and its impact should therefore be communicated separately.

The results presented above depict the average environmental impacts per food item. However, the environmental impact can vary greatly depending on the season a certain product is consumed. Especially the production of vegetables in a heated greenhouse leads to a high environmental impact. Figure 7 shows the environmental impact of strawberries produced in Switzerland in a heated and an unheated greenhouse. Only the heating of the greenhouse increases the environmental impact by 60%. This is due to the use of fossil energy carriers for greenhouse heating, which leads to a higher impact on global warming.

Also, long storage time in controlled atmospheres can enhance the environmental impact of a fruit or a vegetable considerably. Since the data are used to model dietary recommendations, it is reasonable to use average data. The influence of seasonality should nevertheless be communicated separately.

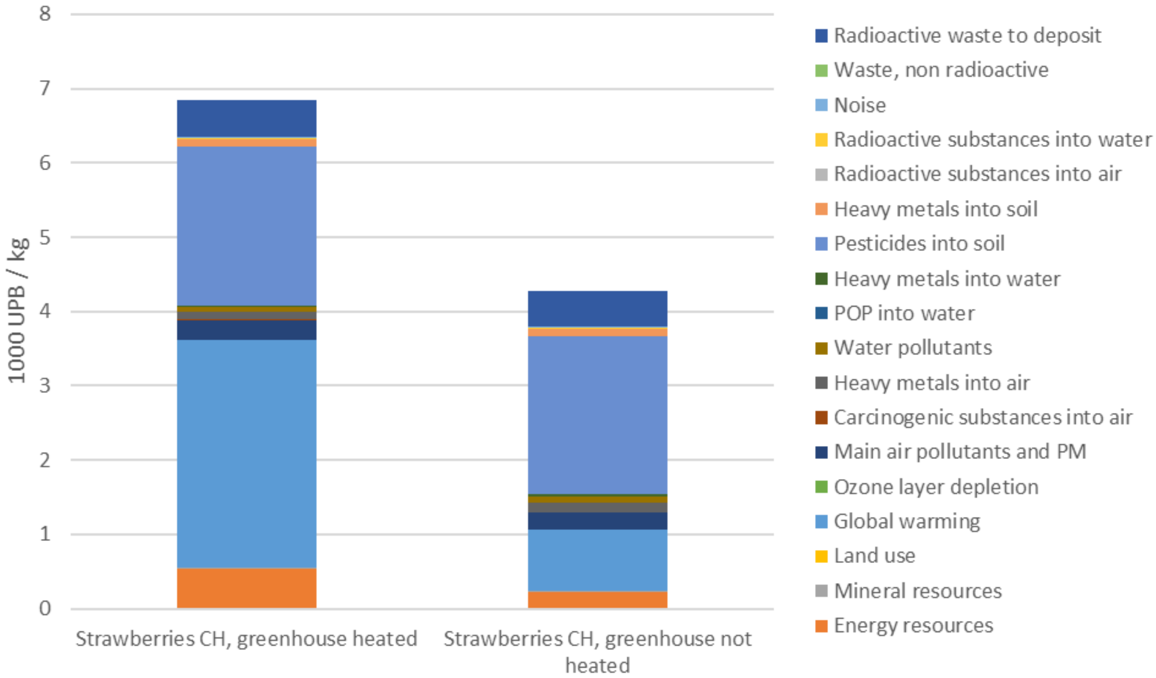

Figure 7: Comparison of environmental impact according to the method of ecological scarcity of 1 kg of strawberries produced in Switzerland, once in a fossil fuel heated and once in an unheated greenhouse.

3.4.4 Sensitivity analysis

Figure 8 shows the environmental impacts of the food items assessed according to three different impact assessment methods: method of ecological scarcity, ReCiPe and global warming potential, in percentage deviation from the mean environmental impact of all products assessed according to the respective method. The profile looks similar for all impact assessment methods: Amongst the food items with the highest impact per weight are coffee, red meat, chocolate, nuts and seeds and vegetable oils.

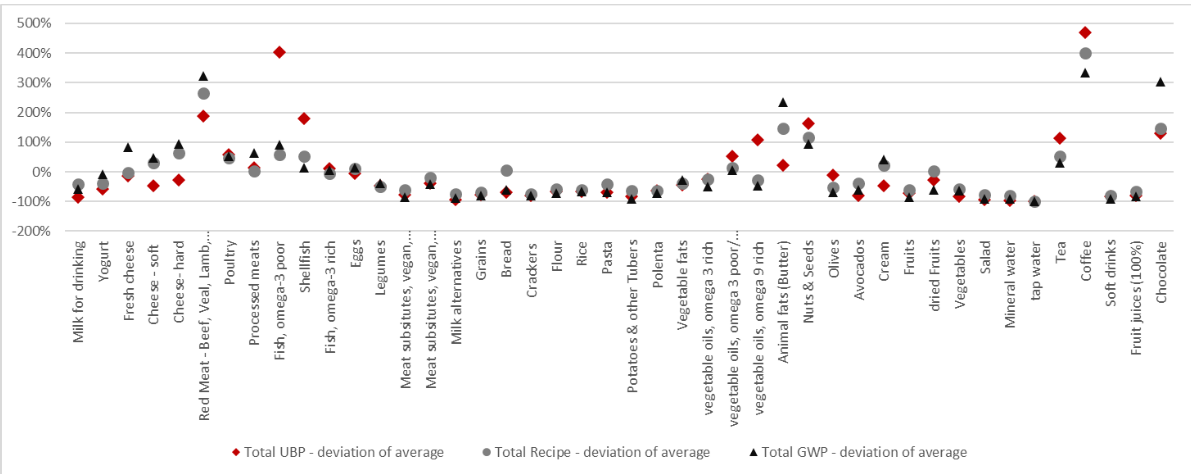

Figure 8: Environmental impact of the different food items assessed according to the method of ecological scarcity, ReCiPe and Global Warming Potential, expressed in percentage deviation from the mean according to the respective impact assessment method.

Differences can be observed for shellfish, omega-3 poor fish, animal fats (butter) as well as vegetable oils. Shellfish only exhibits high results for the method of ecological scarcity, whereas it lies near the average regarding ReCiPe and global warming potential. This is due to the pesticide input in feed production of the farmed shrimps, which is highly rated only in the method of ecological scarcity. Similarly, omega-3 poor fish show high impacts according to the method of ecological scarcity. This is due to the consideration of overfishing in this method. Animal fats (butter) on the other hand show moderate impacts according to the method of ecological scarcity, but higher impacts for ReCiPe and especially global warming potential. This is due to the greenhouse gas emissions, which are more important for the ReCiPe-results and the only impact considered for global warming potential. For vegetable oils, according to the method of ecological scarcity the omega 9-rich oils have a higher impact than the omega 3 poor oils, whereas for the other two methods assessed, it is the other way round. This is mainly due to the different weighting of the pesticides used. In all three methods, the omega 3 rich oils exhibit the lowest impact.

3.4.5 Possibilities and limitations of life cycle assessment methodology

The life cycle methodology used in this project allows the comprehensive assessment and quantification of the environmental impact related to food production, including all relevant life cycle stages. However, there is a considerable data need. Food items are underrepresented in the UVEK-database, so a second, food-specific database had to be used to be able to cover all food products necessary. This of course can lead to problems in data consistency.

Even though the newest eco-factors of the method of ecological scarcity were used, integrating eco-factors for the exploitation of marine fish resources, there are environmental impacts which are not covered (e.g., soil compaction, salinization, microplastics, etc.). Additionally, a life cycle assessment is not a full sustainability assessment. It only covers the environmental dimension of sustainability and does not consider social or economic factors.

With the reference of the results to weight or energy content the focus is on eco-efficiency. This is an important information, but not sufficient to conclude on the environmental sustainability of agricultural production itself.

3.5 Conclusion

The results presented above show the environmental impact of the food items in the Swiss food pyramid. They should be regarded as a first step for integrating environmental information in the Swiss food pyramid, while their representativeness is still to be enhanced. However, together with the health information presented in this report, an assessment of the synergies and trade-offs regarding healthy and sustainable nutrition is possible.

Not all aspects regarding the environmental impact of food are integrated in the results above. As average production is considered, no statement about seasonality is possible. Also, the subject of air transports is not addressed. As these aspects are not primarily depending on the type of food item, but rather on consumer’s choice, they should be separately assessed and communicated. The Foodprints[6] of the Swiss Society for Nutrition could be a valuable complement here.

Considering all impact methods analysed, the food items with the highest environmental impact per weight are red meat, coffee and chocolate, nuts and seeds and animal fats. Uncertainties exist for shellfish, fish, and plant oils. Per energy content especially red meat, poultry and fish exhibit a high environmental impact. These results confirm that a diet with a high intake of red meat is not in line with reaching a sustainable diet. While poultry leads to the lowest environmental impact of all types of meat, it is still higher than vegan meat alternatives. Also, coffee and chocolate are related to a high environmental impact and should not be consumed in big amounts. These recommendations show synergies to the recommendations made from a health perspective. Trade-offs might exist with nuts and seeds - from a health perspective, their intake is recommended, from an environmental perspective that could lead to a higher environmental impact. This trade-off should be further analysed with more specific consumption patterns and information on the agricultural production of nuts and seeds. The recommendation of fish should also be carefully analysed, as its impact is particularly high per kcal.

[6] https://www.sge-ssn.ch/ich-und-du/essen-und-trinken/ausgewogen/foodprints/

However, more detailed analyses, considering possible alternatives to fish, are needed to make reliable statements.

3.5.1 Outlook/Recommendations

The use of a single, comprehensive database for Swiss agricultural production would enhance the reliability of the results. Such a database can in principle be publicly available or created on a private basis. A public database would be more transparent but would first have to be set up. Examples exist e.g., in the field of building products, where a single, comprehensive database exists[7] and companies can add their products with quality-controlled LCAs.

There are various background data on agricultural production in Switzerland. It would be worth considering a way how these data could find entry in LCA-analysis. Pesticide use e.g., is monitored in Switzerland (ZA-AUI PSM[8]). Including this data in the calculation of environmental impacts would greatly increase the reliability of the results for Swiss products.

For some Swiss products, detailed studies on their production are available [e.g., Wolff et al. 2017 (20); Bystricky et al. 2015 (22)], but the corresponding life cycle inventories are not published. Consistent publication of life cycle inventories financed by the public sector could further improve the database.

3.6 References

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[8] See https://www.agroscope.admin.ch/agroscope/de/home/themen/umwelt-ressourcen/monitoring-analytik/agrarumweltindikatoren/psm-aquatische-oekotoxizitaet.html

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4 Comparison of nutritional recommendations

Author: L. Suzanne Suggs, Lucia Sanchez   Reviewers: Esther Infanger, Pedro Marques-Vidal

4.1 Methodology

Using Springmann et al (2020) as a basis (1), the latest food-based dietary guidelines for adults were reviewed for Switzerland, Austria, Germany, France, Italy, Netherlands, United Kingdom, and Sweden. Guidelines of the WHO and the EAT Lancet Commission were also included (see **Table 47**). A data extraction tool was designed to collect information on nutrition guidance per food group, and information and guidance on sustainability categories. The results are presented in tabular form for food groups (see **Table 48**) and sustainability aspects (see **Table 49**).

Table 47: Included guidelines.

Country/author	Latest update	Reviewed guidelines
Switzerland	2020	Schweizer Lebensmittelpyramide. Empfehlungen zum ausgewogenen und genussvollen Essen und Trinken für Erwachsene La pyramide alimentaire suisse. Recommandations alimentaires pour adultes, alliant plaisir et équilibre Piramide alimentare svizzera. Raccomandazioni alimentari per adulti che conciliano piacere ed equilibrio nell'alimentazione Swiss Food Pyramid. Recommendations for a healthy and enjoyable adult diet Source: https://www.sge-ssn.ch/ich-und-du/essen-und-trinken/ausgewogen/schweizer-lebensmittelpyramide/
Austria	2010	Die österreichische Ernährungspyramide (The Austrian food pyramid) Source: https://www.sozialministerium.at/Themen/Gesundheit/Lebensmittel-Ernaehrung/Ern%C3%A4hrungsempfehlungen.html
Germany	2017	Vollwertig essen und trinken nach den 10 Regeln der DGE (Deutsche Gesellschaft für Ernährung) (10 rules of the German Society for Nutrition) Online: Dreidimensionale DGE-Lebensmittelpyramide (Three-dimensional food pyramid), DGE-Ernährungskreis (DGE nutrition circle) Sources: https://www.dge.de/fileadmin/public/doc/fm/10-Regeln-der-DGE.pdf https://www.dge.de/ernaehrungspraxis/vollwertige-ernaehrung/lebensmittelpyramide/
France	2019	Recommandations relatives à l'alimentation, à l'activité physique et à la sédentarité pour les adultes. (Recommendations concerning diet, physical activity, and sedentary behaviour for adults) Source: https://www.santepubliquefrance.fr/determinants-de-sante/nutrition-et-activite-physique/documents/rapport-synthese/recommandations-relatives-a-l-alimentation-a-l-activite-physique-et-a-la-sedentarite-pour-les-adultes

Country/author	Latest update	Reviewed guidelines
Italy	2018	Linee guida per una sana alimentazione (Guidelines for healthy eating) Source: https://www.crea.gov.it/web/alimenti-e-nutrizione/-/linee-guida-per-una-sana-alimentazione-2018
Netherlands	2020	Richtlijnen Schijf van Vijf (Guidelines of the five-disc) Factsheet: Wheel of five Factsheet: Sustainable Eating Source: https://www.voedingscentrum.nl/Assets/Uploads/voedingscentrum/Documents/Professionals/Schijf%20van%20Vijf/Richtlijnen%20Schijf%20van%20Vijf.pdf
Sweden	2015	De Svenska kostråden: Hitta ditt sätt att äta grönare, lagom mycket och röra på dig! The Swedish dietary guidelines: Find your way to eat greener, not too much and be active Source: https://www.livsmedelsverket.se/globalassets/publikationsdatabas/andra-sprak/kostraden/kostrad-eng.pdf?AspxAutoDetectCookieSupport=1
United Kingdom	2018	The Eatwell Guide: A Quick Guide to the Government's Healthy Eating Recommendations, The Eatwell Guide: a More Sustainable Diet Methodology and Results Summary, Vegetarian and vegan diets, Q&A-Eat well. Source: https://www.gov.uk/government/publications/the-eatwell-guide
Eat Lancet Commission (EAT)	2019	Healthy diets from sustainable food systems, Planetary Health Diet Source: https://eatforum.org/eat-lancet-commission/the-planetary-health-diet-and-you/
WHO	2016	Healthy diet Source: https://www.who.int/news-room/fact-sheets/detail/healthy-diet

4.2 Results

4.2.1 Overarching messages

A summary of the key overarching messages of the reviewed guidelines is shown in **Table 48**, next page.

Table 48: Overarching messages

Country / author	Overarching messages
Switzerland	*Food-based* • Eating sweets, salty snacks, and alcohol only in small amounts. • Use oils and nuts in small amounts daily and butter/margarine sparingly. • Consume three servings of dairy products and one serving of meat/fish/eggs/tofu per day. Alternate between protein-rich foods. Watch for calcium in plant-based alternatives to dairy. Consume meat in moderation. Replace meat more often with other protein-rich foods e.g., tofu, legumes or eggs. • Consume three servings of grains, potatoes, and legumes per day. Grains should preferably be whole grains. Legumes are good sources of protein. • Consume five servings of fruits and vegetables per day, including at least three servings of vegetables and two servings of fruit. One portion can be replaced by (unsweetened) juice. Consume a diversity (different colours) of vegetables and fruits. Large portions. • Drink 1-2 litres of unsweetened beverages per day, preferably water. *Not food-based* • At least 30 minutes of physical activity daily and sufficient relaxation.
Austria	*Food-based* • **Non-alcoholic beverages:** Drink at least 1.5 litres of liquid daily, preferably low-energy beverages in the form of water, mineral water, unsweetened fruit or herbal teas or diluted fruit and vegetable juices. • **Vegetables, legumes, and fruit:** Eat 5 servings of vegetables, legumes and fruits daily. Ideally, 3 servings of vegetables and/or legumes and 2 servings of fruit. • **Milk and dairy products:** Consume 3 servings of milk and dairy products daily. • **Fish, meat, sausage, and eggs:** Eat at least 1 - 2 portions of fish per week (approx. 150 g each), eat red meat (such as beef, pork, and lamb) and sausages rather rarely. You can consume up to 3 eggs per week. • **Fats and oils:** Daily 1 - 2 tablespoons of vegetable oils, nuts or seeds. • **Physical activity:** A healthy lifestyle also includes physical exercise - at least 3.5 hours per week. • **Fatty, sweet, and salty foods:** Consume fatty, sugary and salty foods and high-energy drinks infrequently.
Germany	*Food-based* • **Enjoy food diversity:** Take advantage of food diversity and eat a varied diet. Choose mostly plant-based foods. • **Vegetables and fruit - take "5 a day".** Enjoy at least 3 servings of vegetables and 2 servings of fruit a day. The colourful selection also includes legumes such as lentils, chickpeas and beans as well as (unsalted) nuts. • **Choose whole grains.** When it comes to grain products such as bread, pasta, rice and flour, the whole grain variety is the best choice for your health. • **Complete the choice with animal-based foods.** Eat milk and dairy products such as yoghurt and cheese daily, and fish once or twice a week. If you eat meat, then no more than 300 to 600 g per week. • **Use healthy fats.** Give preference to vegetable oils such as canola oil and spreadable fats made from it. Avoid hidden fats. Fat is often "invisible" in processed foods such as sausage, pastries, confectionery, fast food and convenience products.

Country / author	Overarching messages
	• **Cut down on sugar and salt.** Foods and beverages sweetened with sugar are not recommended. Avoid them if possible and use sugar sparingly. Save salt and reduce the amount of high-salt foods. Season creatively with herbs and spices. • **Water is the best choice.** Drink about 1.5 litres every day. Preferably water or other calorie-free beverages such as unsweetened tea. Sugar-sweetened and alcoholic beverages are not recommended. *Not Food-based* • **Prepare food gently.** Cook food as long as necessary and as short as possible, using little water and little fat. Avoid burning food when frying, grilling, baking and deep-frying. • **Eat mindfully and enjoy.** Give yourself a break for your meals and take your time eating. Eating slowly and consciously promotes enjoyment and the sense of satiation. • **1Watch your weight and stay active.** Healthy diet and physical activity go hand in hand. Not only regular exercise is helpful, but also an active daily routine, such as walking or cycling more often.
France	*Food-based* **Increase:** ● Consumption of fruits and vegetables in any form (raw, cooked, natural, prepared, fresh, frozen or canned) to at least 5 servings of fruits and vegetables per day and a small handful of unsalted nuts per day ● Consumption of legumes (beans, lentils, chickpeas, etc.) **Use the following foods:** ● Organic, seasonal, and locally produced foods ● Starchy foods (pasta, bread, rice, semolina, potatoes) that can be eaten daily, with preference given to whole starchy foods ● Fish, twice a week, including one fatty fish (sardines, mackerel, herring, salmon) ● Dairy products (milk, yoghurt, cheese, and cottage cheese), 2 per day for adults. ● Canola, walnut, and olive oil (the added fats - oil, butter and margarine - can be consumed daily in small amounts) **Limit consumption of:** ● Meat, preferring poultry and limiting other meats (pork, beef, veal, mutton, lamb, offal) to 500 g per week ● Processed meat to 150 g per week ● Salty products and salt (to 5 g per day for an adult) ● Sweetened drinks, fatty, sweet, salty and highly processed foods ● Products with a Nutri-score "D" or "E ● Alcohol, not more than two glasses per day and not every day *Not Food-based* **Increase:** ● Physical activity to achieve at least 30 minutes of fast walking per day (climbing stairs, running errands on foot, etc.). meals prepared at home at least twice a week ● *Limit the time spent sitting: take the time to walk a little every 2 hours.* ● *Pay attention to the time you spend on the screen.*
Italy	*Food-based* **More is better:** • More fruit and vegetables • More whole grains and legumes • Drink plenty of water every day **Less is better:**

Country / author	Overarching messages
	• Fats: choose which ones and limit the quantity • Sugar, sweets and sugary drinks: less is more • Salt: less is more • Alcoholic beverages: as little as possible *Not Food-based* • **Balance nutrients and maintain your weight.** Control your weight and stay active
Netherlands	*Food-based* 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, wholemeal 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 • Minimise 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 for which supplementation applies
Sweden	*Food-based* **More:** • Vegetables and fruits • Seafood • Exercise **Switch to** • Wholegrain • Healthy fats • Low fat dairy products **Less** • Red and processed meat • Salt • Sugar **Maintain a balance** *Not Food-based* **More:** • Exercise
United Kingdom	*Food-based* • Eat at least 5 portions of a variety of fruit and vegetables every day

Country / author	Overarching messages
	• Base meals on potatoes, bread, rice, pasta or other starchy carbohydrates; choosing wholegrain versions where possible • Have some dairy or dairy alternatives (such as soya drinks); choosing lower fat and lower sugar options • Eat some beans, pulses, fish, eggs, meat and other proteins (including 2 portions of fish every week, one of which should be oily) Eat more beans and pulses, 2 portions of sustainably sourced fish per week, one of which is oily. Eat less red and processed meat • Choose unsaturated oils and spreads and eat in small amounts • Drink 6-8 cups/glasses of fluid a day • If consuming foods and drinks high in fat, salt or sugar have these less often and in small amounts. • Cutting down on saturated fat • Cutting down on sugar • Cutting down on salt *Not Food-based* • Food labelling: You can tell at a glance if they are high, medium or low in fat, saturated fat, sugars, and salt. For a healthier choice, try to pick products with more greens and ambers and fewer reds. • How much food do I need? Try to eat only as much food as you need and get more active! • Do I need vitamin and mineral supplements? Most people can get all the nutrients their body needs by eating healthily. However, some people do need certain supplements.
EAT	Our food in the anthropocene: healthy diets from sustainable food systems to achieve planetary health diets for nearly 10 billion people by 2050. Setting scientific targets for healthy diets and sustainable food production • Target 1: Healthy diets. Transformation to healthy diets by 2050 will require substantial dietary shifts. • Dietary changes from current diets toward healthy diets are likely to result in significant health benefits. Target 2: Sustainable food production • Strategy 1: Seek international and national commitment to shift toward healthy diets • Strategy 2: Reorient agricultural priorities from producing high quantities of food to producing healthy food • Strategy 3: Sustainably intensify food production to increase high-quality output • Strategy 4: Strong and coordinated governance of land and oceans • Strategy 5: At least halve food losses and waste, in line with UN Sustainable Development Goals
WHO	A healthy diet helps protect against malnutrition and diet-related noncommunicable diseases such as diabetes, heart disease, stroke and cancer. Adopt healthy dietary practices: • Balance calories in with calories out • Limit fat intake • Shift from saturated to unsaturated fats • Eliminate industrially-produced trans fats • Limit sugars and salt intake

4.3 Key similarities and differences

The following points synthesize the key similarities and differences among the reviewed guidelines. For a full summary see **Table 50**. Dietary guidance was disaggregated in 10 food groups to facilitate comparisons. The original food groups of each dietary guidelines can be found in **Table 51**.

- The reviewed guidelines have very similar recommendations for **fruit and vegetables**, 5 servings per day; **water**, 1.5 litres per day; **fish**, 1 or 2 servings per week, except for Sweden that suggests 2 to 3 servings per week; and **nuts & seeds** ranging from 15 to 50 g/day. The EAT recommended intake is the highest (50 g/day; range 0-75). A key difference in **vegetable** recommendations arise from the fact that Sweden includes potatoes in the vegetable group, while Austria, Germany, and the UK include legumes, so they can count for the '5 a day'.
- Guidance on the **starchy food** group varies in included foods, units used, amounts recommended and serving sizes but all guidelines favour wholegrains over refined foods. Recommended intake, when provided, ranges from 180 g/day in the UK to 485 g/day in Germany (mean=338.7). Three countries include a suggested number of servings per day: Switzerland (3 servings), Austria (4 servings), and Italy (6 servings). France, Netherlands, Sweden, and the WHO do not suggest specific intake amounts for starchy foods, although guidance for wholegrains is provided in the Netherlands (at least 90 g/day) and Sweden (80 g/day).
- All the reviewed guidelines include **meat** as part of a broader protein-rich food group, so it can be exchanged for legumes, eggs or other plant-based proteins. Countries that provide separate guidance on **eggs** intake suggest up to 3 per week, except for Italy that recommends 2 to 4.
- Except for the UK, all guidelines suggest to **reduce or moderate meat intake**, limiting suggested consumption to a certain amount. However, the units and intake recommendations vary as some guidelines define amounts for the food group; others specify a range or a maximum intake and other only number of servings. The guidelines that clearly define a limit/maximum weekly intake are Austria (450 g), Netherlands (500 g), Germany (600 g) and EAT (602 g). The low end of the range for EAT is 0 g, as meat is not considered essential for a healthy diet. Austrian and Swiss guidelines suggest eating meat up to 3 times per week. However, the recommendation framing differs as Austrian guidelines suggest up to 3 servings per week as a *maximum* and Swiss guidelines mention 2 or 3 servings per week are *enough*.
- Swiss guidelines do not provide specific suggestions about **red meat**. All the other guidelines suggest either reducing or limiting red meat intake to a certain weekly amount, that range from maximum 98 g in the EAT guidelines to 500 g in French and Swedish guidelines.
- Austria, Netherlands and Sweden discourage consumption of **processed meat** along with red meat. France suggests to "limit charcuterie" to 150 g per week while the UK suggests to "cut down" processed meat to a maximum 70 g/day. Italian guidelines position "transformed and conserved meats" in the group of foods for optional consumption (not indispensable for nutritional needs), so if wanted should be limited to "small quantities".
- Most of the reviewed guidelines encourage the consumption of **legume/pulses**, except for Germany that has a rather neutral framing for legume intake as part of the fruit & vegetable group. Legume recommended intake is usually included in a broader food group and only half of the reviewed guidelines provide separated intake guidance. France suggests at least 2 servings, Netherlands 2-3 servings and Italy 3 servings per week. The EAT reference diet is the only one that suggests specific mean daily amounts (50 g of beans, lentils, and peas, and 25 g of soybeans). The position of legumes within food groups also varies among guidelines. EAT Lancet Commission, Italy, Netherlands, the WHO and the UK include legumes within the protein food group; Austria, Germany, Sweden, and the UK (again) include legumes within the vegetable food group, Switzerland locates legumes within the starchy food group, and France has legumes/pulses in a separate food group.

- Guidelines that include recommended servings of **dairy** range between 2 or 3 servings per day (milk equivalents as defined by Springmann et al 2020, where 10 units of milk are needed to make 1 unit of hard cheese, 1.5 units of milk are needed to make 1 unit of yoghurt). However, the mean suggested amounts vary from 250 g/d by EAT to 1295 g by the Italian guidelines (mean=693.13). The EAT reference diet recommends between 0 and 500 g of milk or equivalents per day. The UK and the WHO do not provide specific reference amounts for dairy.
- Switzerland, Germany, Italy, Netherlands, Sweden, and the UK provide explicit suggestions for vegan and vegetarians. The EAT guidelines do this implicitly by suggesting healthy diets without consumption of meat or dairy (lower range is 0).
- Switzerland, Austria, EAT, Germany, and the UK provide visual representations of their reference diets.
- EAT and the UK explicitly mention the importance of sustainable diets.

4.4 Conclusion

The Swiss dietary recommendations for adults are rather consistent with other countries in terms of their scientific basis. And like others, they include fruit and vegetable, water, and fish recommendations, they suggest that meat is an exchangeable part of the diet, and they encourage the consumption of legumes. What is unique in the Swiss recommendations is that legumes are included in the starchy food group, dairy products are included in the same food group of meat, fish, eggs & tofu instead of a specific category dedicated to dairy. And regarding meat consumption, there is only an implicit recommendation for red meat. All other guidelines explicitly suggest limiting red meat. Switzerland is also unique in its framing of the recommendations themselves. Most countries stress “healthy eating” and “guideline” in the titles of their recommendations, but Switzerland positions a healthy diet as an enjoyable diet and provides recommendation vs rules in the title: “Recommendations for a healthy and enjoyable adult diet”. The joy of eating emphasis is to be commended and built upon. This strategy communicates that a healthy diet is not about what one cannot have, but rather one that give many benefits, including joy.

Table 49: Dietary guidance per food group in selected guidelines.

Country / author	Water & Beverages	Fruits & Vegetables	Cereals, grains, bread, potatoes	Legumes
Switzerland	1 to 2 litres per day Drink water regularly throughout the day, both during and between meals. Choose unsweetened beverages, such as tap water or mineral water, or fruit or herbal teas. Caffeinated beverages, such as coffee, black or green tea, may also contribute to fluid intake.	5 servings a day, of different colours, including 3 servings of vegetables and 2 servings of fruit 1 serving is equivalent to 120 g. One serving per day may be replaced by 2 dl of unsweetened vegetable or fruit juice.	3 portions per day Give preference to whole grain products. One serving equals: • Bread/dough (75-125 g) • Potatoes (180-300 g) • Swedish crackers/wholegrain crackers/flour/pasta/rice/maize/other small grains [dry] (45-75 g)	3 servings of cereal products and whole grains per day One serving equals: • Dry (60-100g)
Austria	At least 1.5 litres of fluid per day Choose low-energy beverages such as water, mineral water, unsweetened fruit or herbal teas, or diluted fruit and vegetable juices.	5 servings of vegetables, legumes and fruit per day Ideally 3 servings of vegetables and/or legumes and 2 servings of fruit One portion equals: • Cooked vegetables (200-300 g) • Raw vegetables (100-200 g) • Salad (75-100 g) • Fruit (125-150 g) • Vegetable or fruit juice (200 ml) Rule of thumb: one clenched fist equals one portion.	4 servings of cereals, bread, noodles, rice or potatoes per day 5 servings for athletically active people and children Give preference to whole grain products One portion equals: • Bread (50-70 g) • Pastries (50-70 g) • Raw pasta (65-80 g • Cooked pasta (200-250 g) • Raw rice or cereals (50-60 g) • Cooked rice or cereals (150-180g) • Cooked potatoes (200-250 g, 3-4 medium sized)	3 servings of vegetables and/or legumes One serving equals: • Raw (70-100 g) • Cooked (150-200 g)
Germany	Drink about 1.5 litres every day. Preferably water or other calorie-free beverages such as unsweetened tea. Sugar-sweetened and alcoholic	At least 3 servings (400 g) of vegetables and at least 2 portions (250 g) of fruit per day (includes legumes such as	4-6 slices (200-300 g) of bread or 3-5 slices of bread (150-250 g) and 50-60 g of cereal flakes AND	Legumes included in Fruit & Vegetable food group. One serving equals: • Raw (~70 g) • Cooked (~125 g)

Country / author	Water & Beverages	Fruits & Vegetables	Cereals, grains, bread, potatoes	Legumes
	beverages are not recommended	lentils, chickpeas and beans, and unsalted nuts)	1 portion (200 - 250 g) potatoes (cooked) or 1 portion (200 - 250 g) pasta (cooked) or 1 portion (150 - 180 g) rice (cooked) Whole grain products preferred	
France	Water is the only drink recommended. Unsweetened tea, coffee (in moderation) and infusions can also serve as water. Fruit juices, sugary drinks and soft drinks, even diet drinks, "energy" drinks must be limited - no more than one glass per day.	At least 5 per day. Recommended portion sizes are 80 - 100g. Increase your consumption regardless of the initial consumption level. No more than one glass of fruit juice per day, which counts as one portion of fruit and vegetables. Favour fresh pressed fruit juice.	To be consumed daily, at least one wholegrain starch per day, and one portion per meal, opting for wholegrain or unrefined products.	At least twice a week as they are naturally rich in fibre. Increase pulses. Pulses may accompany poultry, fish or meat or could also replace meat and poultry; in this case, the recommendation is to serve them with a grain product. If you can, favour organic pulses.
Italy	On average 1.5-2 litres of water per day (at least 6-8 glasses) even between meals. Drink frequently and in small amounts. Drink slowly, especially if the water is very cold.	Eat more fruit, vegetables, and tubers 2.5 portions (standard portion is 200g) of fresh vegetables per day AND 3 portions (standard portion 150 g) of fruits per day	Consume bread, pasta, rice and other grains (preferably whole grains) regularly Bread (3.5 portions of 50 g per day); pasta, rice, corn… (1.5 portions of 80 g per day); bread substitutes, such as biscuits or crackers (1 portion of 30 g per week); baked sweet products* such as brioche, croissant, cornetto (2 portions of 50 g per week); breakfast cereals* such as muesli or corn flakes (2 portions of 30 g per week). potatoes/tubers (2 portions of 200 g per week)	Eat more pulses 3 times per week (standard portion, 150 g or half plate)
Netherlands	Sufficient amount of fluid, such as tap water, tea and coffee	At least 200 g of fruit per day 250 g of vegetables per day	At least 90 g of whole-grain cereal products per day Replace refined cereal products with whole-grain cereal products.	2-3 servings/week (cooked) 1 portion of fish / pulses / meat per day

Country / author	Water & Beverages	Fruits & Vegetables	Cereals, grains, bread, potatoes	Legumes
Sweden	Water is by far the best drink for quenching thirst - much better than fizzy drinks, juice, soft drinks and sports drinks.	Eat lots of fruit, vegetables and berries! Ideally, choose high fibre veggies such as root vegetables, cabbage, cauliflower, broccoli, beans and onions. Eat at least 500 g of vegetables and fruit every day. This is equivalent to two generous handfuls of vegetables, root vegetables and two pieces of fruit. Potatoes aren't included in those 500 g, but they're a good food anyway.	Choose wholegrain varieties when you eat pasta, bread and grain. About 70 g per day for women and 90 g for men. This is equivalent to two pieces of crispbread and a portion of wholegrain pasta, for example.	Discover legumes Eat at least 500 g of vegetables and fruit every day, which is equivalent to two generous handfuls of legumes.
United Kingdom	6-8 cups/glasses of fluid every day Water, lower fat milk and sugar-free drinks including tea and coffee all count. Limit fruit juice and smoothies to no more than a combined total of 150 ml per day.	Eat at least 5 portions of a variety of fruit and vegetables every day. A portion equals 80 g or any of these: 1 apple, banana, pear, orange or other similar-size fruit, 3 heaped tablespoons of vegetables, a dessert bowl of salad, 30 g of dried fruit or a 150 ml glass of fruit juice or smoothie	Choose higher-fibre, wholegrain varieties Base your meals around starchy carbohydrate foods.	Beans, peas and lentils (which are all types of pulses) are good alternatives to meat. Eat more beans and pulses. Pulses can be part of the "5 a day" (fruit & vegetables).
EAT	Not provided	100 to 300 g/day of fruit A planetary health plate should consist of approximately half a plate of vegetables and fruits. Macronutrient intake: • Vegetables (300 g/day; range 200-600) • Fruits (200 g/day; range 100-300)	A planetary health plate should consist of approximately half a plate of primarily whole grains. Whole grains: rice, wheat, corn and other macronutrient intake range: 232 g/day	Global consumption of legumes will have to double, and consumption of foods such as red meat and sugar. Macronutrient intake: 75 g/day; range 0-100

Country / author	Water & Beverages	Fruits & Vegetables	Cereals, grains, bread, potatoes	Legumes
WHO	Not provided	At least 400 g (i.e., five portions) of fruit and vegetables per day excluding potatoes, sweet potatoes, cassava and other starchy roots. 2 cups of fruit (4 servings), 2.5 cups of vegetables (5 servings)	A healthy diet includes whole grains (e.g., unprocessed maize, millet, oats, wheat and brown rice). 180 g/d of grains	A healthy diet includes legumes (e.g., lentils and beans) 160 g of meat and beans

Table 49 (cont.). Dietary guidance per food group in selected guidelines.

Country / author	Dairy / milk	Oils, fats	Nuts & Seeds
Switzerland	3 servings of milk/dairy products per day 1 serving equals: • Milk (2 dl) • Yoghurt (150-200 g) • Semi-hard/hard cheese (30g) • Soft cheese (60g) • Curd/cottage cheese (150-200 g)	2-3 tablespoons per day (20-30 g) of vegetable oil, at least half of which should be in the form of canola oil. Use fats such as butter and margarine, and high-fat milk products sparingly (about 1 tablespoon = 10 g).	1 serving per day (20-30 g) of unsalted nuts (e.g., walnuts) or unsalted seeds.
Austria	3 servings of milk and dairy products per day Prefer low-fat varieties 2 portions of "white" (yoghurt) and 1 portion of "yellow" (cheese)	1-2 tablespoons of vegetable oils, nuts or seeds per day Quality before quantity. E.g. olive oil, rapeseed oil, but also other vegetable oils such as walnut oil, soybean oil Use fats such as butter and margarine, and high-fat milk products sparingly.	1-2 tablespoons of vegetable oils, nuts or seeds per day Nuts and seeds contain valuable fatty acids and can be consumed in moderate quantities.
Germany	Eat milk and dairy products like yoghurt and cheese daily 200-250 g of milk and dairy products and 2 slices (50-60 g) of cheese If you want to save calories, choose the low-fat varieties.	10-15 g/d oil (e.g. rapeseed, walnut or soybean oil) 15-30 g margarine or butter	Nuts included in Fruit & Vegetable food group. 25 g of nuts can replace one serving of fruit.
France	Go towards a sufficient but limited consumption of dairy products. 2 dairy products per day, alternating between milk, yoghurt, cheese and cottage cheese. Butter and cream are not included in dairy products because they are rich in fat.	Every day in small quantities. Avoid excessive consumption. Favour rapeseed and nut oils (rich in ALA) and olive oil instead of oils low in ALA (including sunflower and peanut oils). Animal fats are to be used raw and in a limited quantity.	In addition to fruit and vegetables, the recommendation is to consume a small handful of unsalted nuts each day.
Italy	3 glasses of milk per day [or] 3 yoghurts per day [or] 2-3 portions of fresh cheese per week [or] 2-3 portions of aged cheese per week. Drink every day a glass of milk or yoghurt, preferably skimmed.	Less is better - Fats: choose which ones and limit quantity. Olive oil/vegetable oil (3 spoons of 10ml per day) Butter, fats from animal/vegetable origin (3 portions of 10g per day).	Nuts/oily seeds (30 g): Equivalent to 7-8 walnuts, 15-20 almonds/ hazelnuts, 3 level tablespoons of peanuts or pine nuts or sunflower seeds, etc.

Country / author	Dairy / milk	Oils, fats	Nuts & Seeds
Netherlands	2-3 servings and 40 g cheese per day	Replace saturated fat with unsaturated fat.	At least 15 g/d of unsalted nuts Choose nuts without additives (salt, sugar) and can include peanuts, seeds and kernels.
Sweden	Choose low-fat, unsweetened products enriched with vitamin D. Depending on what else you eat - cheese, for example - 2-5 decilitres of milk or fermented milk a day is all you need to make sure you get enough calcium.	Choose healthy oils when cooking, such as rapeseed oil or liquid fats made from rapeseed oil.	Nuts and seed with fabulous fat Cooking fats aren't our only source of "good" fat - nuts and seeds are full of healthy fats too. Choose the unsalted varieties, of course.
United Kingdom	Go for lower fat and lower sugar products where possible. Swap flavoured or corner-style yoghurts for low fat, lower sugar yoghurts, adding fresh fruit for variety. When buying dairy alternatives, go for unsweetened, calcium-fortified versions.	Choose unsaturated oils and spreads and eat in small amounts. All fat should be limited. Reduce your saturated fat intake.	Nuts (plain) included in protein food group, but no specific recommendation about quantity or frequency of consumption.
EAT	Dairy foods: • Whole milk or equivalents macronutrient intake: 250 g/d; range 0-500	Macronutrient intake: • Unsaturated oils (40 g/d; range 20-80) • Saturated oils (11.8 g/d; range 0-11.8)	Protein sources: • Nuts macronutrient intake (50 g/d; range 0-75)
WHO	Eat reduced-fat dairy foods	To avoid unhealthy weight gain, total fat should not exceed 30% of total energy intake Intake of saturated fats should be less than 10% of total energy intake, and intake of trans-fats less than 1% of total energy intake Shift away from saturated fats (e.g. found in fatty meat, butter, palm and coconut oil, cream, cheese, ghee and lard) and Industrially produced trans fats (found in processed food and fast food). Prefer unsaturated fats. (e.g. found in fish, avocado, nuts, sunflower, canola and olive oils)	A healthy diet includes nuts

Table 49 (cont.). Dietary guidance per food group in selected guidelines.

Country / author	Meat	Fish	Eggs
Switzerland	Consume meat in moderation - 2-3 servings of meat and poultry per week Add one portion of another protein-rich food daily - could be meat, poultry, dairy, or plant-based Alternate between different protein sources One serving equals: meat / poultry / fish / tofu / seitan / quorn (100-120 g)	1 or 2 servings per week (depending on the variety and fat content). Choose fatty marine varieties (e.g., salmon, tuna, herring).	1 serving per day of another protein-rich food (e.g., eggs). 1 serving equals 2-3 eggs.
Austria	Maximum of 3 portions of low-fat meat 300 - 450 g per week Eat red meat rather rarely	At least 1-2 portions of fish (approx. 150 g each) per week Prefer fatty sea fish such as mackerel, salmon, tuna and herring or local cold-water fish such as char.	Up to 3 eggs per week
Germany	Up to 300 - 600 g of low-fat meat and sausage per week	Once or twice a week Prefer fatty sea fish varieties 1 serving equals: • Sea fish such as cod or redfish (80-150 g) • Fatty sea fish such as salmon, mackerel or herring (70 g)	Up to 3 eggs per week
France	Up to 500g of meat per week (excluding poultry) Reduce meat. Give preference to poultry. Limit other meats (pork, beef, veal, mutton, lamb, offal) More pulses and less meat, is good for the environment. Of all foods, meat has the greatest impact on the climate.	Twice a week, including fatty fish (sardines, mackerel, herring, salmon)	For enjoyment and variety, you can alternate during the week between meat, poultry, fish, eggs and pulses.
Italy	1-2 portions of meat, fish, egg, or legumes per day	Consume small size and with a high content in omega-3 polyunsaturated fatty acids Fish (including shellfish, crustaceans and frozen fish): 150g; equivalent to 1 small fish,	1 egg = 50 g; 2-4 times a week

Country / author	Meat	Fish	Eggs
		1 medium fillet, 3 king prawns, 20 shrimp, 25 mussels; 2 times per week Preserved fish: 50g; equivalent to 1 small can of tuna or mackerel in oil or brine, 4-5 thin slices of smoked salmon, ½ cod fillet; 1 time per week	
Netherlands	1 portion of fish / pulses / meat per day Eat more plant-based foods and fewer animal products Consider eating less meat, or no meat at all, and choosing seasonal products more often. A maximum weekly consumption of 500 grams of meat, including meat products, of which a maximum of 300 grams of red meat per week.	Oily fish recommended once a week A portion of fish is 100 g.	2-3 eggs per week (100-150 g per week)
Sweden	Four meals containing meat makes around 500 grams. Focus more on vegetarian foods and eggs, and sometimes fish or poultry. Or eat meat a little more often, but in smaller quantities. Choose eco labelled meats such as free range, organic or certified eco-friendly.	Eat fish and shellfish 2-3 times a week. Vary your intake of fatty and low-fat varieties, and choose eco labelled seafood	Focus more on vegetarian foods and eggs
United Kingdom	Eat less red and processed meat. Choose leaner meat options. Limit processed meats such as sausages, bacon and cured meats. If you eat more than 90 g/d of red or processed meats, try to reduce the amount to no more than 70 g/d.	At least two portions (2 x 140g) of sustainably sourced fish per week including a portion of oily fish.	Eat some eggs
EAT	Global consumption of foods such as red meat will have to be reduced by more than 50%. Protein sources macronutrient intake: • Beef, lamb and pork (14 g/d; range 0-28) • Chicken and other poultry (29 g/d; range 0-58)	Protein sources Fish macronutrient intake (28 g/d; range 0-100)	Protein sources Eggs macronutrient intake (13 g/d; range 0-25)

Country / author	Meat	Fish	Eggs
WHO	Red meat can be eaten 1−2 times per week, and poultry 2−3 times per week. 160 g of meat and beans Eat lean meats, or trimming visible fat from meat.	Not provided	Not provided

Table 50: Sustainability aspects considered in guidelines for adults.

Country / author	Production	Processing	Food miles	Packaging	Diets	Food waste
Switzerland	Choose eco-friendly and animal-friendly food.		Eat seasonal and regional foods.	Drink tap water. Avoid elaborate packaging. Take reusable bags, cloth bags or baskets when shopping. Use reusable containers.	Prefer a plant-based diet. Consume less fish, choose organic and local fish.	Avoid food waste. Store food properly.
Austria			Eat seasonal and regional fruits and vegetables			
Germany	Choose eco-friendly and animal-friendly food. Choose organic-certified fish. Avoid products with non-certified cultivation of palm oil.	Choose eco-friendly cooking methods (use residual heat from the oven and electric hotplates to finish cooking)	Eat seasonal and regional foods.	Drink tap water. Use reusable water containers.	Prefer a plant-based diet.	Avoid food waste. Save edible food regardless of the expiration date.
France	Choose organic foods.	Prefer homemade meals. Prefer fresh foods rather than canned ones.	Eat seasonal and regional foods.	Drink tap water.	Vary foods.	
Italy	Choose organic foods.	Choose eco-friendly cooking methods (microwave and pressure cooker).	Eat seasonal and regional foods.	Drink tap water. Avoid elaborated packaging. Choose products with recyclable packaging.	Eat less red and processed meat.	Prefer frequent grocery shopping. Buy products close to their expiration date. Organize foods at home based on the expiration date.

Country / author	Production	Processing	Food miles	Packaging	Diets	Food waste
						Recycle leftovers in new recipes.
Netherlands	Choose organic foods. Choose sustainable palm-oil products. Make eco-friendly, quality-based choices. Food production should reduce greenhouse gas emissions, usage of pesticides and antibiotics.				Prefer a plant-based diet. Vary foods. Eat less red meat. Choose the right foods in the right amounts.	Avoid food waste.
Sweden	Make eco-friendly choices. Choose organic foods. Choose organic-certified fish. Choose sustainable palm-oil products.		Eat seasonal foods.		Prefer a plant-based diet. Vary foods. Eat less red meat. Limit dairies and fish intake.	Avoid food waste.
United Kingdom	See guidance on sustainably sourced fish.	Prefer homemade meals.			Use the “Eatwell Guide: A More Sustainable Diet”. Eat more beans and pulses. Limit sustainably sourced fish to 2 servings a week. Eat less red and processed meat.	Avoid food waste.
EAT					Prefer a plant-based diet. The ideal plate should include half a	Reduce food loss at the production stage and food waste at

Country / author	Production	Processing	Food miles	Packaging	Diets	Food waste
					plate of vegetables and fruits; the other half should consist of primarily whole grains, plant protein sources, unsaturated plant oils, and (optionally) modest amounts of animal sources of protein.	the consumption side.
WHO		Limit consumption of baked, fried and pre-packaged foods that contain industrially produced trans-fats.				

Table 51: Food group classification.

Country / author	Number of food groups	Food groups used on the reviewed guidelines (sorted)	
Switzerland	6	1. Beverages 2. Vegetables & fruit 3. Cereal products, potatoes and legumes. 4. Dairy products, meat, fish, eggs & tofu	5. Oils, fats and nuts 6. Sweets, salty snacks and alcoholic beverages
Austria	7	1. Non-alcoholic beverages 2. Vegetables, legumes and fruit 3. Cereals and potatoes 4. Milk and dairy products	5. Fish, meat, sausage and eggs 6. Fats and oils 7. Fatty, sweet and salty snacks
Germany	7	1. Beverages 2. Vegetables and salad 3. Fruit 4. Cereals, cereal products and potatoes	5. Milk and dairy products 6. Meat, sausage, fish and eggs 7. Oils and fats
France	8	1. Fruit and vegetables 2. Pulses 3. Wholegrain and unrefined grain products (Unrefined* bread, pasta, rice and other grain products)	4. Dairy products 5. Meat and poultry 6. Fish and seafood 7. Oils, fats and spreads 8. Nuts with no added salt
Italy	5	1. Fruits and vegetables 2. Cereals (and derivatives) and tubers	3. Milk (and dairy products) 4. Meat, fish, eggs and legumes 5. Cooking fats
Netherlands	5	1. Drinks 2. Vegetables and fruit 3. Bread, grain/cereal products and potatoes	4. Dairy, nuts, fish, legumes, meat and eggs 5. Spreading and cooking fats
Sweden	8	1. Vegetables and fruits 2. Wholegrain 3. Low fat dairy products 4. Seafood	5. Red and processed meat 6. Healthy fats 7. Salt 8. Sugar
United Kingdom	5	1. Fruit and vegetables 2. Potatoes, bread, rice, pasta and other starchy carbohydrates	3. Beans, pulses, fish, eggs, meat and other protein 4. Dairy and alternatives 5. Oil and spreads
EAT	8	1. Fruits: all fruits 2. Vegetables: all vegetables 3. Whole grains: rice, wheat, corn and other 4. Tubers or starchy vegetables: potatoes and cassava 5. Dairy foods: whole milk or equivalents	6. Protein sources: beef, lamb and pork, chicken and other poultry, eggs, fish, legumes, nuts 7. Added fats: unsaturated oils, saturated oils 8. Added sugars: all sugars
WHO	NA	No explicit food groups mentioned.	No explicit food groups mentioned.

4.5 References

1 Springmann M, Spajic L, Clark MA, Poore J, Herforth A, Webb P, Rayner, M., & Scarborough, P. The healthiness and sustainability of national and global food based dietary guidelines: Modelling study. *BMJ* 2020;370, m2322. DOI: 10.1136/bmj.m2322

5 Definition of foodstuffs important for the Swiss nutritional guidelines

Authors: Klazine van der Horst, Undine Lehmann, Martina Alig

The definition of foodstuffs of important for the Swiss nutritional guidelines aimed to cover the whole range of foods relevant from a nutritional/health point of view as a priority, and from an environmental point of view as a second step. This food list served as a basis for several work packages to enable connection between the different work packages as well as connecting health and sustainability impact.

5.1 Food list for the association between foods and non-communicable diseases.

The food-groups as in **Table 51** were defined as the food groups of importance for health (NCD) and nutrition recommendations which served as the basis of the literature reviews conducted in chapter 6. It is important to note that for some food groups the level and amount of available evidence limits the further categorization of these foods in sub-groups. This food list was created based on the 2019 FCN report which summarized evidence from 2012-2017 (1) and additional foods as listed in the specifications of the public tender [fruit juices, vegetable oils, fatty foods (nuts, seeds, avocado, olives); soy and soy products].

Table 52: List of food groups to be included in the literature review for dietary recommendations

Food Group	**Food sub-groups**
Milk and dairy	Milk and dairy products - focus on low fat vs full fat products
Meat, fish, eggs	Red meat
	Poultry
	Processed meats
	Fish & fish products, non-fatty
	Fatty fish - Potentially not enough evidence for the difference between fatty and lean fish
	Eggs
Plant proteins and legumes	Legumes (pulses), fresh legumes in vegetables food group
	Milk & dairy alternatives - Distinguish between enriched (e.g., calcium) and not enriched if possible
	Soy and soy products (Tofu)
Cereals and starchy foods	Wholegrains and starchy foods
	Refined grains and starchy foods
	Breakfast cereals (sweetened/unsweetened)
Oils, fats, nuts	Vegetable oils and fats
	Animal fats (butter)
	Nuts, seeds, avocado, olives
Fruits and vegetables	Fruits

Food Group	Food sub-groups
	Vegetables, incl. fresh legumes such as green beans, green peas, snow peas
Beverages	General fluid intake, water
	Coffee
	Sugar sweetened beverages
	Fruit Juices (100%)
Packaged foods and snacks (incl. ultra–processed foods)	Ultra-processed foods

5.2 Food list for the association between foods and sustainability

To answer the question on environmental impact of various foods and to explore potential conflicts between nutritional and environmental impact of foods, the food list of step 1 was further developed. This list would also serve as a basis for the statistical model that will be developed in the future. For the development of this extended list additional food groups were created to reflect all basic 31 food groups used in the Menu CH study (2). Based on the available environmental impact data foods representing these food groups were identified for the Swiss diet. Therefore, the WFLDB and Agribalyse databases were used. The available environmental data, food frequency data from menuCH, together with extensive working group discussions, including the BLV as main stakeholder led to the final food list that will serve as a basis of the statistical model. Because a detailed assessment on organic products was not foreseen, organic foods are left out of the Table.

After the identification of the foods that would represent a food sub-group the weighting factors for these foods were established. For most categories an equal weighting was applied, with all individual food items contributing similar to the environmental impact evaluation of a food category. However, for some foods groups, this would give a distorted picture due to a difference with consumption in the population (e.g., a large environmental impact contribution for foods that are minimally consumed). For these groups, menuCH consumption frequency data was used to calculate the weighting percentages of the foods which are reflected in the final **Table 53**.

With these weighting factors contribution of individual foods to the environmental impact of food subgroups was established and was used for the calculation of environmental impact calculation per 100 gram and per kcal of the food subcategories as is further described under the statistical model. Where relevant the edible part of the food was considered using Delane et al (3), instead otherwise indicated in **Table 54**.

Table 53: List of foodstuffs important for the Swiss nutritional recommendations

Food Group	#	Food subcategories for WP4	Available LCI Data used for calculation of food items (organic excluded)	Weighting	Edible part %
Milk & dairy	1	Milk for drinking	Milk, semi-skimmed	50%	100%
			Milk, whole	50%	100%
	2	Yoghurt	Yoghurt natural (3.6% Fat)	33.4%	100%
			Yogurt with fruits, with sugar	33.3%	100%
			Yogurt with chocolate shaving, with cream, with sugar	33.3%	100%
	3	Cheese, fresh	Cream cheese, min 60% fat in dry mass	50%	100%
			Mozzarella	50%	100%
	4	Cheese, soft	Soft cheese (average without fat reduced products)	100%	100%
	5	Cheese, hard	Hard and semi hard cheese, full fat (average)	100%	100%
Meat, fish, eggs	6	Red meat – beef, veal, lamb, pork, horse	Beef (average excluding offal, chop), raw	47%	100%
			Pork (average excluding offal, chop, knuckle), raw	34%	100%
			Veal (average excluding offal, chop), raw	9%	100%
	7	Poultry	Chicken, breast, raw	100%	100%
	8	Processed meats	Cooked smoked sausages (average)	20%	100%
			Minced meat (average of beef, veal, pork, chicken), pan fried (without addition of fat and salt)	20%	100%
			Poultry nuggets	20%	100%
			Cooked cured meat (average)	20%	100%
			Salami	20%	100%
	9	Fish, omega-3 poor	Fish, sole, raw	12.5%	100%
			Cod, raw	12.5%	100%
			Saithe, pollock, raw	12.5%	100%
			Bass, raw	6.3%	100%
			Eurasian perch, raw	6.3%	100%
			Trout, farmed, raw, smoked	12.5%	100%
			Trout, farmed, ray, fresh	12.5%	100%
			Tuna in oil, drained	12.5%	100%
			Pangasius, filets, cooked (shark catfish)	12.5%	100%
	10	Shellfish	Shrimp, raw	50%	33%

Food Group	#	Food subcategories for WP4	Available LCI Data used for calculation of food items (organic excluded)	Weighting	Edible part %
			Molluscs, blue mussel, raw	25%	49%
			Scallop, raw	25%	80%
	11	Fish, omega-3 rich	Fish, tuna, raw	40%	100%
			Fish product, anchovy in oil, drained	5%	100%
			Fish product, sardine in oil, drained	5%	100%
			Rollmops (pickled herring)	5%	100%
			Salmon, wild, raw	22.5%	100%
			Salmon, cultured, raw	22.5%	100%
	12	Eggs	Egg, raw	100%	88%
Vegetable & alternative Proteins	13	Legumes	Chickpeas	33.4%	100%
			Lentils	33.3%	100%
			Soybean	33.3%	100%
	14	Meat substitutes, vegan, minimally processed	Falafel (deep fried in HOLL rapeseed oil)	50%	100%
			Tofu	50%	100%
	15	Meat substitutes, vegan, highly processed	Mycoprotein (Quorn)	50%	100%
			Pea patty (Beyond Meat)	50%	100%
	16	Milk alternatives	Oat drink, plain (Average of branded products)	33.4%	100%
			Almond drink, plain (Average of branded products)	33.3%	100%
			Soya drink, plain	33.3%	100%
Cereals and starchy foods	17	Grains	Oat flakes	33.4%	100%
			Millet, grain peeled	33.3%	100%
			Durum wheat semolina	33.3%	100%
	18	Bread	Bread (average)	100%	100%
	19	Crackers	Rusk	50%	100%
			Crispbread, wholemeal	50%	100%
	20	Flour	Flour (average)	50%	100%
	21	Rice	Rice polished raw	100%	100%
	22	Pasta	Pasta, egg-free, dry	50%	100%
			Pasta with egg, dry	50%	100%

Food Group	#	Food subcategories for WP4	Available LCI Data used for calculation of food items (organic excluded)	Weighting	Edible part %
	23	Potatoes & other tubers	Potato, peeled, raw	98%	83%
			Sweet potato, raw	2%	100%
	24	Polenta	Corn semolina, dried	100%	100%
Oils, fats, nuts	25	Vegetable fats	Margarine, 70%	100%	100%
	26	Vegetable oils, omega 3 rich	Rapeseed oil	90%	100%
			Flaxseed oil, cold pressed	10%	100%
	27	Vegetable oils, omega 3 poor/ other oils	Sunflower oil	90%	100%
			Coconut fat	10%	100%
	28	Vegetable oils, omega 9 rich	Olive oil	90%	100%
			Peanut oil	10%	100%
	29	Animal fats (Butter)	Cooking butter	100%	100%
	30	Nuts & seeds	Hazelnut	25%	40%
			Cashew nut	25%	67.5%
			Walnut	25%	100%
			Almond	25%	100%
	31	Olives	Olive, black	100%	77.5%
	32	Avocados	Avocado, fresh	100%	74%
	33	Cream	Cream (average)	100%	100%
Fruits and vegetables	34	Fruits	Apple, fresh	35%	91%
			Banana, raw	18%	66%
			Mandarin, fresh	9%	77%
			Orange, fresh	8%	74%
			Peach, fresh	7%	78%
			Pear, raw	6%	87%
			Strawberry, fresh	3.3%	90%
			Grape, fresh	3.5%	93%
			Kiwi fruit, raw	5%	98%
			Apricot, raw	5%	98%
	35	Dried fruits	Raisins, dried (grape)/sultanas	25%	100%
			Apricot, dried	25%	100%

Food Group	#	Food subcategories for WP4	Available LCI Data used for calculation of food items (organic excluded)	Weighting	Edible part %
			Apple, peeled, dried	25%	100%
			Fig, dried	25%	100%
	36	Vegetables	Tomato, raw	28%	100%
			Mushroom (average)	22%	89%
			Broccoli, raw	10%	93%
			Carrot, raw	8%	97%
			Bell pepper, red, raw	7%	85%
			Zucchini, raw	7%	95%
			Cucumber raw	4%	97%
			Bean, green, raw	4%	88%
			Onion, raw	4%	88%
			Spinach, raw	6%	86%
	37	Salad	Leafy salad, average, raw	100%	94%
Beverages	38	Mineral water	Drinking water (average CH)	100%	100%
	39	Tap water	Drinking water (average CH)	100%	100%
	40	Tea	Tea, no sugar added	100%	100%
	41	Coffee	Coffee, instant, powder	50%	100%
			Coffee, black, no sugar added	50%	100%
	42	Soft drinks	Soft drink, with flavour, sweetened	100%	100%
	43	Fruit juices (100%)	Orange juice	70%	100%
			Apple juice	30%	100%
Snacks	44	Chocolate	Milk chocolate	50%	100%
			Chocolate, dark	50%	100%

Table 53 (cont): List of foodstuffs important for the Swiss nutritional recommendations

Food Group	#	Food subcategories for WP4	Swiss Food Composition Database (SFCD)	ID SFCD	Kcal/100g or ml[9]
Milk & dairy	1	Milk for drinking	Milk, semi-skimmed	1194	62*
			Milk, whole	1194	62*
	2	Yoghurt	Yoghurt natural (3.6% Fat)	52	66
			Yogurt with fruits, with sugar	1192	105
			Yogurt with chocolate shaving, with cream, with sugar	1192	105
	3	Cheese, fresh	Cream cheese, min 60% fat in dry mass	567	351
			Mozzarella	82	256
	4	Cheese, soft	Soft cheese (average without fat reduced products)	1197	325
	5	Cheese, hard	Hard and semi hard cheese, full fat (average)	1193	397
Meat, fish, eggs	6	Red meat – beef, veal, lamb, pork, horse	Beef (average excluding offal, chop), raw	1103	134
			Pork (average excluding offal, chop, knuckle), raw	1102	160
			Veal (average excluding offal, chop), raw	1106	128
	7	Poultry	Chicken, breast, raw	22 - 20	130
	8	Processed meats	Cooked smoked sausages (average)	1112	249
			Minced meat (average of beef, veal, pork, chicken), pan fried (without addition of fat and salt)	13317	164
			Poultry nuggets	Ciqual ANSES	239
			Cooked cured meat (average)	1118	223
			Salami	1118	223
	9	Fish, omega-3 poor	Fish, sole, raw	755	85
			Cod, raw	285	76
			Saithe, Pollock, raw	754	80
			Bass, raw	765	79
			Eurasian perch, raw	765	79
			Trout, farmed, raw, smoked	289	127
			Trout, farmed, ray, fresh	289	127

[9] Foods expressed per 100 ml are indicated with an *

Food Group	#	Food subcategories for WP4	Swiss Food Composition Database (SFCD)	ID SFCD	Kcal/100g or ml[9]
			Tuna in oil, drained	418	186
			Pangasius, filets, cooked (shark catfish)	Ciqual ANSES	79
	10	Shellfish	Shrimp, raw	766	56
			Molluscs, blue mussel, raw	761	85
			Scallop, raw	Ciqual ANSES	83
	11	Fish, omega-3 rich	Fish, tuna, raw	756	149
			Fish product, anchovy in oil, drained	414	182
			Fish product, sardine in oil, drained	413	215
			Rollmops (pickled herring)	805	270
			Salmon, wild, raw	210	182
			Salmon, cultured, raw	194	200
	12	Eggs	Egg, raw	290	140
Vegetable & alt. proteins	13	Legumes	Chickpeas	1133	336
			Lentils	1133	336
			Soybean	1133	336
	14	Meat substitutes, vegan, minimally processed	Falafel (deep fried in HOLL rapeseed oil)	14066	222
			Tofu	13437-8	90
	15	Meat substitutes, vegan, highly processed	Mycoprotein (Quorn)	See note [10]	85
			Pea patty (Beyond Meat)		
	16	Milk alternatives	Oat drink, plain (Average of branded products)	13426	43
			Almond drink, plain (Average of branded products)	13428	44
			Soya drink, plain	72	40
Cereals and starchy foods	17	Grains	Oat flakes	198	381
			Millet, grain peeled	422	360
			Durum wheat semolina	423	353

[10] https://www.quornnutrition.com/importance-of-micronutrients

Food Group	#	Food subcategories for WP4	Swiss Food Composition Database (SFCD)	ID SFCD	Kcal/100g or ml[9]
	18	Bread	Bread (average)	10446	264
	19	Crackers	Rusk	930	428
			Crispbread, wholemeal	918	332
	20	Flour	Flour (average)	1135	343
	21	Rice	Rice polished raw	427	352
	22	Pasta	Pasta, egg-free, dry	800	353
			Pasta with egg, dry	799	365
	23	Potatoes & other tubers	Potato, peeled, raw	813	76
			Sweet potato, raw	13406	81
	24	Polenta	Corn semolina, dried	425	350
Oils, fats, nuts	25	Vegetable fats	Margarine, 70%	208	724
	26	Vegetable oils, omega 3 rich	Rapeseed oil	600	810*
			Flaxseed oil, cold pressed	13405	810*
	27	Vegetable oils, omega 3 poor/ other oils	Sunflower oil	598	810*
			Coconut fat	601	894
	28	Vegetable oils, omega 9 rich	Olive oil	591	810*
			Peanut oil	596	810*
	29	Animal fats (Butter)	Cooking butter	51	745
	30	Nuts & seeds	Hazelnut	270	661
			Cashew nut	275	593
			Walnut	271	709
			Almond	273	624
	31	Olives	Olive, black	492-3	165
	32	Avocados	Avocado, fresh	380	144
	33	Cream	Cream (average)	1195	252
Fruits and vegetables	34	Fruits	Apple, fresh	378	55
			Banana, raw	381	95
			Mandarin, fresh	397	47
			Orange, fresh	405	44
			Peach, fresh	401	48
			Pear, raw	382	58

Food Group	#	Food subcategories for WP4	Swiss Food Composition Database (SFCD)	ID SFCD	Kcal/100g or ml[9]
			Strawberry, fresh	385	40
			Grape, fresh	478	69
			Kiwi fruit, raw	395	54
			Apricot, raw	379	48
	35	Dried fruits	Raisins, dried (grape)/sultanas	477	321
			Apricot, dried	469	293
			Apple, peeled, dried	435	295
			Fig, dried	387	273
	36	Vegetables	Tomato, raw	348	21
			Mushroom (average)	1128	29
			Broccoli, raw	351	31
			Carrot, raw	355	38
			Bell pepper, red, raw	360	32
			Zucchini, raw	367	19
			Cucumber raw	354	14
			Bean, green, raw	353	31
			Onion, raw	368	39
			Spinach, raw	365	23
	37	Salad	Leafy salad, average, raw	1127	18
Beverages	38	Mineral water	Drinking water (average CH)	522	0*
	39	Tap water	Drinking water (average CH)	47	0*
	40	Tea	Tea, no sugar added	803	0*
	41	Coffee	Coffee, instant, powder	983	253
			Coffee, black, no sugar added	994	2*
	42	Soft drinks	Soft drink, with flavour, sweetened	595	38*
	43	Fruit juices (100%)	Orange juice	576	51*
			Apple juice	568	45*
Snacks	44	Chocolate	Milk chocolate	195	537
			Chocolate, dark	196	537

Table 54: Additional information regarding the foodstuffs important for the Swiss nutritional guidelines

Food Group	Food items	Comments
Milk & dairy	(1) Milk for drinking	To reflect milk consumption in the population we choose to use the average milk that is a mix of low fat, milk drink and full fat milk.
	(2) Yoghurt	We differentiated between natural and sweetened yoghurt. Sweetened yoghurt are relevant from a sustainability point of view.
Meat, fish, eggs	(7) Poultry	For nutrient calculation we used 50% chicken breast with skin and 50% without skin to get an average nutrient intake.
	(8) Processed meats	Meat balls: The kcal and nutrient values do not contain the fat used for preparation. This could be included in the Modelling.
		Chicken nuggets: In the Table we added the French Ciqual ANSES data for chicken nuggets. In case a Swiss nutrient value needs to be used we propose as alternative option the chicken burger with ID 13460. This might include the nutrient values including the bread (sandwich) which needs to be checked.
	(9, 11) Fish (omega 3 rich and poor)	Tuna was split in canned (low fat, and omega 3) and the fresh tuna was added to the omega 3 rich fish. We agreed on weighting factors with total salmon 45%, tuna 40% other fatty fish 15%
		Difficult to find data for Pangasius. In the French nutrient database, a value for cooked fish fillet is provided. As an alternative we propose to use the average whitefish with ID 211 and 101 kcal.
	(10) Shellfish	Shrimp: edible part was based on cooked shrimps
		Scallop, as an alternative the same nutrients as for mussels can be used from the Swiss food composition database.
Vegetable and alternative proteins	(13) Legumes	We used nutrition value for dried soybeans. Potentially re-calculation of data needed if for the environmental impact calculation data from fresh soybeans was used
	(14) Meat substitutes, vegan, minimally processed	No data on Seitan was available. For Tofu we used the 2 available types of tofu for the nutrient calculation due to the difference in calcium.
	(15) Meat substitutes, vegan, highly processed	No nutrient data in the public database.
	(16) Milk alternatives	For the milk alternatives we have only branded products with limited nutrition data in the Swiss Database. This data could potentially be taken from the Ciqual ANSES database. There is only environmental data on the non-fortified versions, but from an environmental point of view, there is not much difference expected. It can be a suggestion to factor in some “theoretical” fortification during the modelling phase.

Food Group	Food items	Comments
Oils & fats	(25) Vegetable fats	In the Swiss nutrient database, the available product is the 80% fat margarine. However also many light versions are on the market. Therefore, we propose either to use the Ciqual average product with 30-40% fat or to remove this food from the list.
	(26,27,28) Oils	For oils we used a similar weighting for all groups of 90% of the most commonly used oil and 10% for another less commonly used oil that was available in the database.
	(30) Nuts and seeds	Hazelnuts: the edible part was defined based on following publication: Milošević, Tomo & Milošević, Nebojša. (2017). Determination of size and shape features of hazelnuts using multivariate analysis. *Acta Scientiarum Polonorum. Hortorum cultus = Ogrodnictwo*. 16. 10.24326/asphc.2017.5.6.
		Cashew nuts: the edible part was defined based on following publication that was retracted www.hindawi.com/journals/isrn/2013/147365/. However, no other data source could be found and the reasons for retraction do not lead us to think that this value is incorrect.
	(31) Olives	We used the two available foods in the nutrient database to calculate an average kcal value. Edible part for olives at farm ranged between 70-85% and therefore we used 77.5%. Source: Rocha, J., Borges, N., & Pinho, O. (2020). Table olives and health: a review. *Journal of Nutritional Science*, *9*, e57. https://doi.org/10.1017/jns.2020.50
Fruits & vegetables	(34) Fruits	Fruits represent a mix of most frequently consumed products based on Menu CH and data availability.
	(36) Vegetables	Fruits represent a mix of most frequently consumed products based on Menu CH and data availability. Herbs were excluded.
		The edible factor for chili pepper is 73% and for Paprika or bell pepper 85%. Adapt according to final product choice.
		Beans: edible part was set at 88% for green, wax and snap bean from the USDA handbook 'food yields summarized by different stages of preparation'.
Beverages	(38) Mineral water	We used the nutrition values for tap water to have an average nutrition value instead of getting a skewed calculation based on the mineral water we choose.
	(41) Coffee	Coffee Instant Powder refers the unprepared product without water added.

5.3 References

1. Federal Committee for Nutrition (FCN). Reappraisal of the scientific evidence linking consumption of foods from specific food groups to non-communicable diseases. An expert report of the federal commission for nutrition (FCN/ EEK) Bern, December 2019. Bern, Switzerland: Federal Food Safety and Veterinary Office; 2019, 31 December.

2. Chatelan A, Beer-Borst S, Randriamiharisoa A, Pasquier J, Blanco JM, Siegenthaler S, Paccaud F, Slimani N, Nicolas G, Camenzind-Frey E, Zuberbuehler CA, Bochud M. Major differences in diet across three linguistic regions of Switzerland: Results from the first national nutrition survey menuCh. *Nutrients*. 2017;9(11). DOI: 10.3390/nu9111163.

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6 Compiling data for the statistical model

Author: Undine Lehman

The following table summarizes data derived from the reviews of food groups in relation to NCD (WP3). The reported minimum, optimal and maximum amounts of food groups per NCD were stated. If it was not possible to allocate a specific NCD, the term “Various” was used. As expected, and described in the research proposal, in most cases there are no scientific data available to define the exact minimum, maximum and optimum amounts. In this case, the most frequent data from dietary recommendations from the comparison of dietary recommendations (WP5) were used to complete the data. However, it must be noted that the reviewed dietary guidelines also differ in their recommendations or do not include all of the food groups in such detail. They were only cited if there is a certain consensus / the recommendation appears in more than one country. Furthermore, recommendations from the FCN report 2019 (1) were stated when available.

Table 55: Estimation of minimum, optimal, and maximum daily amount of food groups in relation to NCD.

Food group	NCD	Minimum	Maximum	Optimal	Derived from dietary recommendations	Derived from last FCN report (FCN 2019)
Beverages						
Green Tea	CVD	-	-	1 L		
Water	Various				1.5 L	-
Coffee	Various		<4 cups	2–3 cups		safe up to 4 cups
SSBs	Various	0	0	0		-
Fruit juice	Various	-	0	0		
Fruits and vegetables						
Fruits	CVD	200 g	-	400 g		
Fruits	Obesity/weight gain	-	-	3 servings (~360 g*)		
Vegetables	CVD	200 g	-	400 g		
Fruits and vegetables	Various				5 servings	200-300 g of vegetables and 200-300 g of fruit = up to two servings of whole fruits and up to ≥ three servings of vegetables
Cereals & starchy foods						
Potato, boiled, baked or mashed	Various	-	100 g	-		
Potato, fried	Various	-	-	0 g		
Whole grain	Various	50 g	-	90 g	Favour whole grain over refined grain	
Starchy foods	Various				Varies between countries, mean 340 g	Three daily serving of cereal and starchy foods be consumed daily, and that as many as possible should be from whole grain. 75–125 g bread/pastry (preferably whole grain products), or 60–100 g legumes/pulses (dry

Food group	NCD	Minimum	Maximum	Optimal	Derived from dietary recommendations	Derived from last FCN report (FCN 2019)
						weight), or 180–300 g potatoes, or 45–75 g crisp bread/whole-grain/crackers/flakes/flour/pasta/rice/corn/other grains (dry weight).
Meat, fish and eggs						
Red meat	Various	0	0	0		Maximal consumption of three portions of red unprocessed meat per week. Three portions is equivalent to about 350 to 500 grams cooked weight in total
Processed meat	Various	0	0	0		WCRF/AICR recommend consuming very little, if any, processed meat, ANSES recommend a maximal consumption of 25 g of processed meat
Meat					Maximum 450–600 g/week. Red meat maximum 98–500 g/week. Processed meat to limit.	
Fish	CVD	>0 g	90 g	50 g		
Fish	Various				1–2 servings	ANSES recommends consuming fish one to two times per week (1 portion=100 g). It further specifies that consumption of fatty, deep-sea fish should be limited to one serving per week to avoid excessive exposure to toxicological compounds present in these type of fishes, and that the second weekly fish serving

Food group	NCD	Minimum	Maximum	Optimal	Derived from dietary recommendations	Derived from last FCN report (FCN 2019)
						should be from another type of fish [11]
Eggs	T2D	1 / week	2 / week	1		
Eggs	Various				up to 3 / week	
Meat, fish, eggs	Various					More attention should be paid to a diversification of protein sources, including proteins of plant origin
Milk and dairy products						
Milk and yoghurt	Stroke	400 g §; RR between 0.92 and 0.98 per increment of 200 g (for yoghurt 100 g) §	-	-		
Milk	Bladder cancer	227 ml §	-	-		
Fermented dairy	Bladder cancer	67 g §	-	-		
Whole milk	Bladder cancer	-	220 g §			
Total dairy	Colon cancer	400 g §	-	-		
Milk/fermented milk	Colon cancer	200 g §	-	-		
Cheese	Colon cancer	200 g §	-	-		

[11] Agence nationale de sécurité sanitaire de l'alimentation de l'environnement et du travail. (2016) Actualisation des repères du PNNS: révision des repères de consommations alimentaires. https://www.ANSES.fr/fr/system/files/NUT2012SA0103Ra-1.pdf. Accessed 7 Sept 2022

Food group	NCD	Minimum	Maximum	Optimal	Derived from dietary recommendations	Derived from last FCN report (FCN 2019)
Cottage cheese	ER- breast cancer	25 g §	-	-		
Yoghurt	ER- breast cancer	60 g §	-	-		
Dairies	Insulin resistance	3-5 servings #	-			
Total dairy	T2D	270 g §	-	-		
Yoghurt	T2D	100 g §; RR 0.94 per increment of 100 g §	-	-		
Low fat milk	T2D	200 g §	-	-		
Cheese	T2D	-	40 g §			
Low fat dairies	Obesity	4-5 servings #	-	-		
Low fat milk	Obesity	200 ml #	-	-		
Dairies within diets	Obesity	2-4 servings #	-	-		
Dairy	General					Consumption of three portions
Legumes, pulses and soy						
Legumes/ pulses	Various				2–3 servings / week	No clear recommendation. SGE currently recommends 1 serving of a protein-rich food (meat, poultry, fish, eggs, tofu, *quorn*, *seitan*, cheese or cottage cheese; in addition to three portions of dairy foods). 60–100 g legumes/pulses (dry weight) as one of the three cereal servings
Plant protein		-	-	-		
Ultra-processed foods						

Food group	NCD	Minimum	Maximum	Optimal	Derived from dietary recommendations	Derived from last FCN report (FCN 2019)
UPF	Various	0	-	0		
Oils and fats						
Vegetal fats	Various	1 tablespoon oil	20 g	-		
SFA	Various	20 g	24 g	-		
Oils and fats	Various					No clear amounts given; current Swiss Food Pyramid recommendation requires revision
Nuts and seeds						
Nuts and seeds	Various				15–50 g	1 serving, 10–30 g

Values are for a daily intake, unless otherwise stated. For milk and dairy products: § cohort studies; # randomized controlled trials; ER: oestrogen receptor; SSBs, sugar-sweetened beverages; UPF, ultra-processed foods. The given values showed a decrease (in the Min column) or increase (in the Max column) in disease risk in the indicated studies. Only studies with quantitative indications are given, the list is therefore not complete.

6.1 References

1. Federal Commission for Nutrition. Reappraisal of the scientific evidence linking consumption of foods from specific food groups to NCD - report. Bern, Switzerland 2019. 119 p.

7 Restrictions

This report is an update of the 2019 FCN report “Reappraisal of the scientific evidence linking consumption of foods from specific food groups to non-communicable diseases”. As the methodology and food grouping differed, it was not feasible to merge the two reports. Therefore, it was decided, to report the 2019 FCN findings into each food group subchapter (see chapter 2) and to declare new or contradictory findings. Also, and as in the 2019 report, the target population of this report was healthy adults (aged 18+ years); younger people or specific conditions (i.e., pregnancy, lactation, and disease) were not considered.

Furthermore, during the literature search, it became evident for the authors that many studies associating foods to NCD failed to provide dose-response results. Hence, and somewhat surprisingly to the authors, in many cases it was not possible to present data regarding which amounts of food should be consumed to prevent NCD. As a recommendation, it would be seminal that future meta-analyses provide dose-response relationships enabling the assessment of food intake ranges providing health benefits.

8 Summary and conclusion

NCD represent a major burden of morbidity and mortality worldwide as well as in Switzerland. An unhealthy diet is the most important risk factor for NCD, and accounts for approximately 80% of Swiss healthcare costs. The Swiss food based dietary guidelines are one of the measures within the Swiss Nutrition Policy to enable the Swiss population to eat a healthy, varied and balanced diet. The last major update of the current dietary guidelines goes back to 2011. The Federal Food Safety and Veterinary Office FSVO commissioned the project team to update the 2019 report from the FCN and complete it with information on ecological effects of food consumption.

The present report therefore focused on literature from 2018 to 2021 for the foods present in the 2019 FCN report and from 2015 onwards for new foods. It summarises the associations between food groups and different NCD, and takes ecological effects of food production and consumption into account. It also lists and compares dietary guidelines from neighbouring countries and major international organisations. The data provided relate to healthy adults in the age range 18 to 65 years. Other age groups such as toddlers, children, adolescents or elderly, or specific physiological conditions such as pregnancy and lactation, were not considered. Also, dietary recommendations aimed at mitigating existing diseases such as diabetes or obesity were not considered.

The report is the result of a collaborative task of researchers from all over Switzerland, who joined efforts to summarize a large body of literature and data. The authors hope that the herewith provided body of data and information will benefit the Swiss population and lead the path to a healthier, sustainable diet. It shall serve the FSVO as a scientific basis to review and update the current dietary guidelines.

The major findings are as follows:

From a nutritional point of view, most of the current Swiss dietary guidelines for healthy adults can be maintained. However, the following aspects need to be revisited:

- Fruit (and vegetable) juices: Move from “fruit and vegetable” group to top level of pyramid with “sugared and sweetened beverages” as fruit juices do not provide the same health effects as whole fruits.
- Potatoes: Limit (deep-)fried potato products as there is strong evidence of adverse health effects on several NCDs.
- Meat, fish, eggs: Promote diversification of protein sources, including plant-based alternatives more clearly. This will reinforce the consumption of vegetarian protein sources and the limitation of meat (especially red and processed varieties) and fish.

- Dairy products: Promote diversification as fermented products (yoghurts) seem to have beneficial health effects. No need to focus on fat content of dairy products, but restrict sweetened dairies. Consider having a specific category for dairy products (separate from other protein sources).
- Legumes and pulses: Reconsider position and move from “starchy level” to “protein level” to promote the consumption of plant-based protein sources.
- Ultra-processed foods: Limit consumption as evidence for detrimental health effects is growing.
- Nuts, seeds, oleaginous foods: Reconsider position in the food pyramid to promote consumption
- Oils, fats: No need to limit butter as suggested by 2019 FCN report.

In many cases it was not possible to define an optimal intake of the food considered, as most results presented were for a change in consumption (i.e., a one-portion increase) rather than for a given amount consumed. We strongly recommend that future studies on the association between foods and NCDs include a dose-response graph where the effect of different amounts consumed can be visualized. It should also be stressed that, when available, the recommended amounts should not be taken for granted, and should be considered taking into account the gender, body size, and physical activity levels of the person. Favouring the consumption of more beneficial foods over others will be more effective than imposing specific amounts for each food type or group.

Recommendations towards a healthy eating might either be consistent or in conflict with environmental issues, as indicated in the **table 56**. We considered *synergy* for the following combinations of recommendations and environmental issues: “consumption recommended” + “low environmental impact” and “consumption not recommended” + “high environmental impact”, and *conflict* otherwise (for example, “consumption recommended” + “high environmental impact”). Most foods with a high environmental impact (e.g. red meat or chocolate) should also be limited for health reasons. The health benefits of fish, legumes, nuts & seeds are mitigated by their higher environmental impact, while the environmental impact for fruits & vegetables is low compared to other food groups (on the production method). Eggs, cereals & starchy foods combine health benefits and an average environmental impact. Fruit juices have a low environmental impact but their health benefits are non-existent. Overall, **any dietary recommendation will have a certain environmental impact**, which can be reduced if adequate products and production methods are chosen. In this context, it must also be taken into account that undesirable environmental effects can in turn have a negative impact on health.

Table 56: current Swiss dietary recommendations and corresponding environmental issues.

Pyramid level	Food group	Current recommendation (Swiss food pyramid)	Optimal consumption amount based on health evaluation	Environmental evaluation	Conflict or synergy between health and environment
Beverages (bottom level of pyramid)	Water	1-2 litres per day, preferably unsweetened beverages	Not possible to derive an optimal amount based on the literature review.	Tap and mineral water have the lowest environmental impact of all beverages. Tap water should be preferred over mineral water as it has a lower impact (no packaging, no CO_2 production).	Synergy
	Coffee	Part of 1-2 litres. No limit on caffeinated beverages for healthy adults	1 to 6 cups per day, the amounts differ based on the literature review.	Coffee has one of the highest environmental impacts of all beverages (even when considering the small amount of coffee needed for one cup). Consumption should be reduced.	Conflict
	Tea (black, green)	Part of 1-2 litres. No limit on caffeinated beverages for healthy adults	Green tea: 1 litre per day	Even though the environmental impact of tea is relatively high compared to other beverages, only a small amount of tea is needed per cup. No restriction in consumption is recommended. As the main impact stems from pesticide use, organic tea might be an alternative.	Synergy
	Herbal, fruit tea	1-2 litres per day, preferably unsweetened beverages	Not part of this report		
Beverages (in top level of pyramid)	Sugar sweetened beverages	Moderate / limit consumption: 1 serving = 2-3 dl	No consumption	Sweetened beverages have a higher environmental impact than water. It is recommended to reduce the consumption.	Synergy
	Artificially sweetened beverages	Moderate / limit consumption: 1 serving = 2-3 dl	No consumption		
Fruit + vegetables	Fruit	2 portions per day (including fruit juice): 1 serving = 120 g	360-400 g per day	Compared to other food groups fruits have a low environmental impact per weight, however slightly higher than vegetables. Whenever possible, prefer local seasonal fruits to exotic fruits.	Synergy

Pyramid level	Food group	Current recommendation (Swiss food pyramid)	Optimal consumption amount based on health evaluation	Environmental evaluation	Conflict or synergy between health and environment
Fruit + vegetables				No restriction in consumption is recommended.	
	Vegetables	3 portions per day: 1 serving = 120 g	360-400 g per day	Compared to other food groups vegetables have a low environmental impact per weight and a lower impact than fruits. Whenever possible, prefer local seasonal vegetables. No restriction in consumption is recommended.	Synergy
	Fruit and/or vegetable juices	Max. 1 portion per day: 1 serving = 2 dl / unsweetened, unsalted	Fruit juice: No consumption Vegetable juice: not possible to derive an optimal amount based on the literature review.	The environmental impact of fruit juices is in the same range as sweetened beverages. Water exhibits a much lower impact. It is recommended to reduce the consumption.	Synergy
Starchy foods	General	Prefer whole grain to refined grain	Whole grain: 50-90 g per day Refined grain: no consumption	Starchy foods have a low environmental impact per weight and kcal compared to other food groups. No restriction in consumption is recommended.	
	Bread, dough	3 servings of starchy foods per day: 1 serving = 75-125 g	Not possible to derive an optimal amount on the literature review.	Compared to other starchy foods bread has a higher environmental impact per kcal, and an average impact per weight.	No conflict
	Dried legumes	3 servings of starchy foods per day: 1 serving = 60-100 g	1 serving/day	Legumes have a higher environmental impact per weight than the other starchy foods (from pesticide, land use change or direct emissions from composting depending on legume). However, their impact is lower than meat. Special attention has to be paid to a	Conflict

Pyramid level	Food group	Current recommendation (Swiss food pyramid)	Optimal consumption amount based on health evaluation	Environmental evaluation	Conflict or synergy between health and environment
				environmental friendly production	
Starchy foods	Potatoes, starchy roots	3 servings of starchy foods per day: 1 serving = 180-300 g	Boiled or baked: max. 100 – 212 g per day (not possible to derive an optimal amount based on the literature review) Fried: no consumption	Compared to other starchy foods potatoes have a low environmental impact per weight and a high impact per kcal. No restriction in consumption is recommended.	Synergy (boiled or baked)
	Crackers, flakes, flour, dry pasta, rice, maize or other cereals	3 servings of starchy foods per day: 1 serving = 45-75 g	Not possible to derive an optimal amount based on the literature review.	Crackers, flour, pasta, rice, or maize all have a similar and average environmental impact per weight and kcal compared to other starchy foods. No restriction in consumption is recommended.	Synergy (crackers, pasta)
Protein sources and dairy products	Milk	3 servings of dairy per day: 1 serving = 200 ml	>200 ml per day (not possible to derive an optimal amount based on the literature review)	Milk has the lowest environmental impact per weight of all dairy products and a relatively low impact across all food groups. No restriction in consumption is recommended.	Synergy
	Yoghurt	3 servings of dairy per day: 1 serving = 150-200 g	Min. 60 g per day (not possible to derive an optimal amount based on the literature review)	Compared to other food groups yoghurt has a relatively low environmental impact per weight and kcal. Compared to other dairy products yoghurt has the highest environmental impact per kcal but one of the lowest per weight. The impact is especially high when additional ingredients (such as chocolate) are added. Plain yoghurt should be preferred.	Synergy (if no additional ingredients) Conflict (if additional ingredients)
	Quark, cottage cheese	3 servings of dairy per day: 1 serving = 150-200 g	Cottage cheese: >25 g per day	Compared to other cheese products cottage cheese has the lowest environmental impact per weight and kcal if	Synergy

Pyramid level	Food group	Current recommendation (Swiss food pyramid)	Optimal consumption amount based on health evaluation	Environmental evaluation	Conflict or synergy between health and environment
Protein sources and dairy products				considering the lower milk input. The impact is average compared to other food groups. No restriction in consumption is recommended.	
	Cheese as dairy	3 servings of dairy per day: 1 serving = 30 g (hard cheese) or 60 g (soft cheese)	Min. 50 gr per day (not possible to derive an optimal amount based on the literature review)	The impact of soft cheese is lower than the impact of hard cheese (less milk required). The impact is average compared to other food groups – lower than meat, but higher than plant-based protein sources.	Synergy (soft) Conflict (hard)
	Cheese as protein source	1 serving of protein source per day / vary between sources: 1 serving = 30 g (hard cheese) or 60 g (soft cheese)		The impact of soft cheese is lower than the impact of hard cheese (less milk required). The impact is average compared to other food groups – lower than meat, but higher than plant-based protein sources.	Synergy (soft) Conflict (hard)
	Meat	1 serving of protein source per day / vary between sources: 1 serving = 100-120 g / max. 2-3 times a week (incl. processed meat)	Red meat: 0 – 40 g per day	Meat has one of the highest environmental impacts per weight and kcal of all foods and beverages (enteric fermentation and/or feed). It is recommended to reduce the consumption and prefer poultry over pork and especially red meat.	Synergy
	Processed meat, sausages, etc.	1 serving of protein source per day / vary between sources: 1 serving = 100-120 g / max. once a week	No consumption	Processed meat has a relatively high environmental impacts per weight and kcal of all foods and beverages (enteric fermentation and/or feed). It is recommended to reduce the consumption and	Synergy

Pyramid level	Food group	Current recommendation (Swiss food pyramid)	Optimal consumption amount based on health evaluation	Environmental evaluation	Conflict or synergy between health and environment
Protein sources and dairy products				prefer processed poultry over pork and especially red meat	
	Fish and seafood	1 serving of protein source per day / vary between sources: 1 serving = 100-120 g / 1-2 times a week for health - max. once a month for sustainability	50 g per day	Fish has a high environmental impact per weight and kcal compared to other food products (from feed and/or boat use). It is recommended to reduce the consumption. Sustainably farmed or sustainable fished fish should be preferred over seafood.	Conflict
	Egg	1 serving of protein source per day / vary between sources: 1 serving = 2-3 eggs (ca. 100-150 g)	1 egg per week up to 1 egg per day	Compared to other food groups eggs have an average environmental impact per weight and kcal. It is similarly high as cheese, lower than the impact of meat but higher than the impact of plant-based protein sources.	Synergy
	Tofu, Seitan, Tempeh, Quorn etc.	1 serving of protein source per day / vary between sources: 1 serving = 100-120 g	Not possible to derive an optimal amount based on the literature review.	The impact per weight and kcal from meat substitutes is low compared to other food groups and much lower than that of regular meat. No restriction of consumption is recommended. Minimally processed meat alternatives should be preferred over highly processed meat substitutes.	Synergy
Fats, oils, nuts and seeds	Fats (margarine butter, cream)	Max. 10 g per day	<25 g per day (Not possible to derive an optimal amount based on the literature review.)	Fats have a relatively high environmental impact especially per weight compared to other food groups. It is recommended to reduce the consumption. Plant-based fats should be preferred over animal-based fats.	Synergy

Pyramid level	Food group	Current recommendation (Swiss food pyramid)	Optimal consumption amount based on health evaluation	Environmental evaluation	Conflict or synergy between health and environment
Fats, oils, nuts and seeds	Vegetable oils	20-30 g per day	1 – 2 tablespoons (equivalent to 10 – 20 g) per day	Vegetable oils have a relatively high environmental impact especially per weight compared to other food groups (from pesticide and fertilizer). The impact varies depending on the type of vegetable oil. It is recommended to reduce the consumption, especially of omega 9-rich oils.	Synergy (most oils) Conflict (omega 9-rich)
	Nuts and seeds	20-30 g per day (unsalted)	>10 g per day (unsalted nuts) (Not possible to derive an optimal amount based on the literature review. No studies were found for seeds.)	Compared to other food groups and other fat sources nuts and seeds have a high environmental impact especially per weight (from pesticide and/or land use change). It is recommended to reduce the consumption.	Conflict
	Avocado	1 small handful can replace 1 soup spoon (10 g) of oil	No studies were found for avocados.	The environmental impact per weight and kcal of avocado is relatively low compared to other food groups and other fat sources. No restriction in consumption is recommended.	Synergy
	Olives	1 small handful can replace 1 soup spoon (10 g) of oil	No studies were found for olives.	Olives have a relatively high environmental impact per weight and kcal compared to other food groups (from pesticides). Especially the impact per kcal is the highest of all fat sources. It is recommended to reduce the consumption.	Conflict

Pyramid level	Food group	Current recommendation (Swiss food pyramid)	Optimal consumption amount based on health evaluation	Environmental evaluation	Conflict or synergy between health and environment
Sweet, salty, alcoholic	Chocolate	Moderate consumption: 1 serving = 1 row of chocolate	Not part of this report	Chocolate has a high environmental impact per weight compared to other food groups (from land use change) It is recommended to reduce the consumption.	Synergy 
	Sugar	Moderate consumption: max. 10% of energy intake	Not part of this report	Not part of this report	--
	Sweet snacks	Moderate consumption: 1 serving = 1 row of chocolate or 1 ice cream scoop or 3 biscuits	Not part of this report	Not part of this report	--
	Salty snacks	Moderate consumption: 1 serving = small handful (20-30 g)	Not part of this report	Not part of this report	--
	Alcoholic beverages	Moderate consumption: 1 serving = 1 standard drink (2-3 dl beer or 1 dl of wine)	Not part of this report	Not part of this report	--