ECRONICON OPEN ACCESS

EC NUTRITION
Research Article

Healthy Italian Dietary Pattern to Achieve 2030 Climate Target

Raffaela Piccinelli[1], Deborah Martone[1], Giovina Catasta[1], Aida Turrini[2] and Marika Ferrari[1]*

[1]*Research Centre for Food and Nutrition, Council for Agricultural Research and Economics, Rome, Italy*

[2]*Independent Expert (Formerly Council for Agricultural Research and Economics), Italy*

***Corresponding Author:** Marika Ferrari, Council for Agricultural Research and Economics - Research Centre for Food and Nutrition (CREA - Alimenti e Nutrizione), Via Ardeatina, Rome, Italy.

Received: April 25, 2023; **Published:** May 09, 2023

Abstract

Objective: To identify dietary patterns among Italian adults satisfying nutritional recommendations and that meet Green Houses Gas Emissions (GHGE) reduction target to 2030 designed to limit the global average temperature to rise to 1.5°C.

Method: Three dietary patterns were considered: a) a Healthy Dietary pattern (HDp) developed quantifying the food groups and subgroups on the basis of Italian Dietary Guidelines (IDG); b) an Optimized Dietary pattern (ODp) based on daily food groups amounts from an Optimized Diet at lower GHGE close to the current Italian food consumption; c) a Low GHGE Healthy Dietary pattern (Low GHGE HDp), developed from HDp, where the frequencies of minor food subgroups with lower GHGE were increased respect to those with higher, maintaining the frequencies of major food groups. For all three dietary patterns, standardized serving sizes were used. For the 1990 diet, data from the INN-CA Study 1994-96 were used and GHGE emissions were calculated and reported for the adult population. GHGE (in kg CO_2eq) and nutrient content of all dietary patterns have been compared to each other.

Results: With respect to the GHGE from INN-CA food consumption data, HDp shows a GHGE reduction of 31.9% while ODp of 46.8%. For Low GHGE_HDp the choice of different subgroups and minor subgroups, considering their GHGE values, translated into a GHGE reduction of 49.4%. To reach the 55% target, an additional 2030 Target GHGE Dietary pattern was developed, reducing the daily servings' size frequencies of "milk and yoghurt" subgroups respect IDG by a third and shifting the subgroups' frequencies without modifying those of the relative groups, i.e. excluding "pasta with eggs, fillings, etc" and "preserved fish" subgroups and considering only "seasoned cheese" minor subgroups as "cheese" group.

Conclusion: To fully reach the environmental target for the reduction of GHGE, it is enough to reduce the weekly frequency of servings' size for "milk, milk product and yoghurt and fermented milk" group to the Italian healthy dietary pattern and address the choice to "seasoned cheese" among the minor subgroup of "cheese and substitutes" subgroup ensuring equally optimal nutritional coverage.

Keywords: *Diet; Healthy; Environment; Serving Size; Nutritional Recommendations*

Abbreviations

DRVs: Dietary Reference Values (DRVs); ELCRD: EAT Lancet Commission Reference Diet [25]; FBDG: Food-Based Dietary Guidelines; GHGE: Greenhouse Gas Emission; HDp: Healthy Dietary Pattern; IDG: Italian Dietary Guidelines for Healthy Eating [16,17]; LCA: Life-

Cycle Assessment; LARN: Levels of Reference Intake of Nutrients and Energy for the Italian Population [20]; Low GHGE_HDp: Low GHGE Healthy Dietary Pattern; OD: Optimized Diet; ODp: Optimized Dietary Pattern; 2030TargetGHGE_Dp: 2030 Target GHGE Dietary Pattern

Introduction

The Paris Agreement on climate change [1] has established the reduction of Green House Gas Emission (GHGE), and the implementation of measures for adaptation to climate change, aimed at increasing the ability of countries to adapt to the effects adverse to climate change. Signatory countries aim to reach the global peak of emissions as soon as possible and make rapid reductions to achieve the global balance between emissions and removals in the second half of the century. In June 2021, the EU adopted a European Climate Law [2] that sets an intermediate target of reducing GHGE by at least 55% by 2030 compared to 1990 levels and achieving climate neutrality by 2050. In relation to food and agriculture, emission reduction stemming from changing consumer choices toward healthy diets could be of the same order of magnitude to reduce emissions in the sector by 2030 [3]. In line with the Farm to Fork Strategy, consumers should be facilitated to choose sustainable and healthy food and diets. This would not only help the agricultural and food sector to reduce emissions and food waste but also improve consumers' health and reduce health-related costs for society. The biological activity performed by the different bioactive compounds present in healthy food had been shown to be of great importance for the prevention of human cancers, cardiovascular disease, diabetes and metabolic disorders [4].

Sustainable Healthy Diets are defined as "dietary patterns that promote all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable, safe, and equitable; and are culturally acceptable" [5].

Dietary guidelines are the main tools for consumer advice and policy development on healthy food choices. In the past, they were based on the current evidence to reduce the risk of diet-health relationships and to translate dietary reference values for nutrient intake into daily/weekly food portion frequency [6]. However, this approach neglected the aspects of environmental sustainability that could have an indirect effect on human health [7] and lifestyle as environmental, economic, and social implications. The integration of sustainability in all policies including dietary ones is essential to minimize mostly environmental challenges [8].

The dietary guidelines of developed countries such as in Europe are a step forward towards the promotion of sustainable diets [8-10]. A recent review explored the degree of agreement of current Food-Based Dietary Guidelines (FBDGs) in the world to the sustainability guiding principles. A general poor alignment, especially for environmental impact and socio-cultural aspects, was found and the highest rate of inclusion was observed in the European countries [11].

On the other hand, healthy and lower GHGE diets could be created in all income quintiles but tailoring changes to income groups to minimize deviation may make dietary changes more achievable [12].

Recently, mathematical methods and data processing are evolving as a powerful tool to optimize diet nutritiously, economically, and environmentally [13], and in this way, diets recommended in healthy eating guidelines could have an even greater environmental impact than the current average diet.

Benchmarking observed diet is an approach adopted in the data envelopment analysis, especially to maximize cultural acceptance in designing dietary patterns where less-is-better 'unhealthy' nutrients and more-is-better 'healthy' nutrients [14].

The Italian scenario [15], named Italian Optimized Diet (OD), considered the optimal daily portions of foods that could minimize gas emissions while maintaining an adequate nutritional intake as much as possible. In this study, we aimed to identify dietary patterns among Italian adults that satisfied nutritional requirements and remained below GHGE target. On this scope, we calculated food system GHGE target for 2030 designed to limit the global average temperature to rise to 1.5°C.

Materials and Methods

Dietary patterns definition

The study assessed three different dietary patterns. The Healthy Dietary Pattern (HDp) in which food groups and subgroups were quantified as daily amounts and weekly frequencies recommended by the Italian Dietary Guidelines for Healthy Eating (IDG) [16,17]. The Optimized Dietary Pattern (ODp) in which food groups and subgroups were quantified as weekly frequencies by the daily amounts resulted from an Optimized Diet (OD) at lower GHGE close to the Italian food consumption observed in 2005-2006 [15]. Subsequently, a Low GHGE Healthy Dietary Pattern (Low GHGE HDp) was developed from HDp where the frequencies of minor food subgroups with lower GHGE were increased with respect to those with higher, maintaining the frequencies of major food groups of HDp.

For all the assessed three dietary patterns, standardized serving sizes were used [16,17].

Dietary patterns are synthetized in table 1.

Dietary Pattern	Acronym	Definition
Healthy Dietary pattern	HDp	Dietary plan in line with the Italian Dietary Guidelines (IDG) [16,17]
Optimized Dietary pattern	ODp	Dietary plan in line with the optimized diet (OD) [15] at lower GHGE observed in the Italian population.
Low GHGE Healthy Dietary pattern	Low GHGE HDp	HDp transformation increasing frequencies of minor food groups with lower GHGE and decreasing those at higher GHGE.

Table 1: *Dietary patterns definition used for the study.*

Dietary patterns development

Food datasets from the last national dietary survey named "INRAN-SCAI 2005_06" were used. The datasets referred exclusively to subjects 18 - 60 aged and were described in detail by Leclercq., *et al*. [18] and Sette., *et al*. [19]. The use of the datasets for the development of dietary patterns is reported in detail in the Supplementary material. GHGE values (kg CO_{2eq}/Kg) were applied for each food item to calculate the environmental impact as in Ferrari., *et al*. [15].

The food datasets included 971 food items for subjects aged 18 - 60 years and, for this study, 603 food items were considered after exclusion of dietary supplement foods (n = 86), and 282 food items not applied with nutritional composition particular or no appropriate for an adult healthy population (i.e. baby foods, celiac foods, powered foods, etc.), as shown in detail in table S1 in Supplementary Material.

In the food datasets from "INRAN SCAI 2005-2006" food items were aggregated into 15 food groups and 55 food subgroups [18]. 12 food groups and 30 food subgroups with a daily amount > 0g were considered in the Odp as long as 3 food groups were not included in the solution of the optimization [15]. 11 food groups were considered in HDp and Low GHGE_HDp after the exclusion of the "Sweet products and substitutes" group reported as "occasional consumption" in IDG [16,17] while among the 30 food subgroups 3 were split into minor subgroups to facilitate their quantification and distribution of frequencies as recommended by the IDG. In Low GHGE_HDp, 25 subgroups were considered. Details on food grouping are reported in table S2 in Supplementary Material.

The average values of the nutrients of ODp, HDp, and Low GHGE_HDp were obtained by calculating for each food subgroup and minor subgroup the weighted average for the respective number of consumers (18 - 60 years) of the INRAN-SCAI 2005-06 survey of the selected food items.

For the ODp on the base of serving sizes of IDG, the frequencies were calculated by considering the mean daily intake of the OD [15]. While for the HDp and Low GHGE_HDp, the amounts were defined by reporting the same serving sizes and daily and weekly frequencies of the IDG [16,17].

To analyze the nutritional compositions of all dietary patterns were used the Dietary Reference Values (DRVs) for energy and macro- and micro-nutrients as defined by the Levels of Reference Intake of Nutrients and Energy for the Italian Population (LARN) [20]. The GHGE of the food subgroups and minor subgroups values were reported in Ferrari., *et al*. [15].

GHGE target related to dietary pattern

The goal set in September 2021 as part of the Green Deal by the European Commission was taken as a reference with a reduction of greenhouse gas emissions to at least 55% compared to 1990 levels [21].

The study estimated that in the 1990's the GHGE of food consumed in Italy was approximately $3.3_{\text{kg CO2eq}}$ per day (data not published, based on the Italian population by age and gender in 1994-96) [22]. Using the estimated GHGE level of this survey as a baseline, the 55% GHGE reduction target was calculated to be equivalent to $1.49_{\text{kg CO2eq}}$ for the daily food consumption.

Results and Discussions

Serving sizes, weekly frequencies, and daily amounts

Table 2 shows serving sizes, weekly frequencies, and daily amounts of food groups, subgroups, and minor subgroups in the ODp, HDp, and Low GHGE_HDp. The daily amount of "meat, meat products and substitutes", "fish and seafood", "fruit" were higher in HDp and Low GHGE_HDp (42.9g, 50.0g, 458.6g, respectively in both dietary patterns) vs. ODp (32.0g, 20.0g, 181.1g respectively). Also "vegetables" group resulted in being higher for HDp (414.3g) and for Low GHGE_HDp (465.7g) vs. ODp (318.9g).

			ODp			HDp			Low GHGE_HDp			*Daily amount by IDG***	
GROUPS	**SUBGROUPS**	**MINOR SUBGROUPS**	**Serving size (g)**	**Weekly Frequency (n)**	**Daily amount (g/die)**	**Serving size (g)**	**Weekly Frequency (n)**	**Daily amount (g/die)**	**Serving size (g)**	**Weekly Frequency (n)**	**Daily amount (g/die)**		
MILK, MILK PRODUCTS, AND THEIR SUBSTITUTES					***329.9***			***403.6***			***400.0***		
	milk, and milk substitutes*		125.0	13.8	245.7	125.0	14.0	250.0	125.0	14.0	250.0	*125g*	*3/day*
	yoghurt and fermented milk		125.0	4.1	72.6	125.0	7.0	125.0	125.0	7.0	125.0		
	cheese, and substitutes		66.7^	1.2	11.6								
		soft cheese, excl. sheep cheese				100.0	1.0	14.3	100.0	0.5	7.1	*100g*	*3/week*
		seasoned cheese, excl. sheep cheese				50.0	1.0	7.1	50.0	1.5	10.7	*50g*	
		hard cheese, excl. sheep cheese				25.0	1.0	3.6	50.0	1.0	7.1	*50g*	
		sheep cheese (soft and hard)				25.0	1.0	3.6				*50g*	
CEREALS, CEREAL PRODUCTS, AND SUBSTITUTES					***340.1***			***328.9***			***326.1***		
	bread and flour		50.0	25.3.0	180.4	50.0	24.5	175.0	50.0	24.5	175.0	*50g*	*3.5/day*
	breakfast cereals					30.0	2.0	8.6	30.0	2.0	8.6	*30g*	*2/week*
	pasta with eggs, filled, etc.		125.0	0.7	12.1	125.0	1.5	26.8	125.0	1.5	26.8	*125g*	*1.5/day*
	pasta, and pasta substitutes*		80.0	7.4	84.7	80.0	4.5	51.4	80.0	7.5	85.7	*80g*	
	rice		80.0	0.9	9.8	80.0	4.5	51.4	80.0	1.5	17.1	*80g*	
	biscuits		30.0	9.0	38.5	30.0	1.0	4.3	30.0	2.0	8.6	*30g*	*2/week*
	cake and sweet snacks					50.0	1.0	7.1				*50g*	
	savoury fine bakery products		30.0	3.4	14.7	30.0	1.0	4.3	30.0	1.0	4.3	*30g*	*1/week*
MEAT, MEAT PRODUCTS, AND SUBSTITUTES					***32.0***			***42.9***			***42.9***		
	beef & veal, not preserved, excl. offal					100.0	0.5	7.1				*100g*	*1/week*
	pork, not preserved, excl. offal		100.0	0.7	10.0	100.0	0.5	7.1	100.0	1.0	14.3	*100g*	
	poultry and game, not preserved, excl. offal		100.0	1.5	22.0	100.0	2.0	28.6	100.0	2.0	28.6	*100g*	*2/week*
FISH AND SEAFOOD					***20.0***			***50.0***			***50.0***		
	crustaceans, shellfish, mussels					150.0	1.0	21.4				*150g*	*2/week*
	fish, fresh		150.0	0.9	20.0	150.0	1.0	21.4	150.0	2.0	42.9	*150g*	
	fish, preserved					50.0	1.0	7.1	50.0	1.0	7.1	*50g*	*1/week*

GROUPS	SUBGROUPS	MINOR SUBGROUPS	ODp Serving size (g)	ODp Weekly Frequency (n)	ODp Daily amount (g/die)	HDp Serving size (g)	HDp Weekly Frequency (n)	HDp Daily amount (g/die)	Low GHGE_HDp Serving size (g)	Low GHGE_HDp Weekly Frequency (n)	Low GHGE_HDp Daily amount (g/die)	*Daily amount by IDG***	
PULSES					***29.0***			***42.9***			***21.4***		
	pulses, fresh, dried, or processed*		100.0	2.0	29.0								
		pulses, dried				50.0	1.5	10.7	50.0	3.0	21.4	*150g*	*3/week*
		pulses, fresh				150.0	1.5	32.1				*50g*	
EGGS					***25.4***			***21.4***			***21.4***		
	eggs		50.0	3.6	25.4	50.0	3.0	21.4	50.0	3.0	21.4	*50g*	*3/week*
POTATOES *					***124.4***			***57.1***			***57.1***		
	potatoes, excl. crisps*		200.0	4.4	124.4	200.0	2.0	57.1	200.0	2.0	57.1	*200g*	*2/week*
FRUIT					***181.1***			***458.6***			***458.6***		
	citrus fruits and other fruits, excl exotic fruits*		150.0	8.0	172.3	150.0	14.0	300.0				*150g*	*3/day*
		citrus fruits							150.0	15.0	321.4	*150g*	
		other fresh fruits							150.0	6.0	128.6	*150g*	
	exotic fruits					150.0	7.0	150.0				*150g*	
	nuts, seeds, dried fruits, olives, and their products		30.0	2.1	8.8	30.0	2.0	8.6	30.0	2.0	8.6	*30g*	*2/week*
VEGETABLES					***318.9***			***414.3***			***465.7***		
	leafy, fruiting, and other vegetables, fresh		200.0	9.1	260.8								
		leafy vegetables, fresh				200.0	2.0	57.1	200.0	6.5	185.7	*200g*	*2.5/day*
		leafy salad				80.0	5.0	57.1	80.0	2.0	22.9	*80g*	
		fruiting vegetables, fresh				200.0	2.0	57.1	200.0	1.0	28.6	*200g*	
		other vegetables, fresh				200.0	2.0	57.1	200.0	1.0	28.6	*200g*	
		mushrooms				200.0	1.5	42.9	200.0	2.0	57.1	*200g*	
	roots and onions, fresh		200.0	1.9	53.0	200.0	5.0	142.9	200.0	5.0	142.9	*200g*	
	spices and herbs		5.0	6.9	4.9								
OILS & FATS					***40.5***			***30.0***			***30.0***		
	olive oil		10.0	12.5	17.9	10.0	6.0	8.6	10.0	5.0	7.1	*10g*	*3/day*
	other vegetables oil (excl. soyabean oil) *		10.0	4.8	6.9	10.0	5.0	7.1	10.0	9.0	12.9		
	butter, cream, and other fats*		10.0	9.4	13.5	10.0	5.0	7.1					
		butter							10.0	2.0	2.9		
		cream											
		other fats											
	soyabean oil and soyabean butter*		10.0	1.5	2.2	10.0	5.0	7.1	10.0	5.0	7.1		
SWEET PRODUCTS AND SUBSTITUTES					***19.5***								
	ice cream, and substitutes		40.0	1.0	5.6							*Occasional*	
	chocolate and substitutes		25.0	1.0	3.6							*Occasional*	
	candies, jam, and other sweet products*		4.0	4.0	2.3							*Occasional*	
	sugar, fructose, honey, and other nutritious sweeteners		8.0	7.0	8.1							*Occasional*	
NON-ALCOHOLIC BEVERAGES					***1458.3***			***1600.0***			***1600.0***		
	tap water*		200.0	21.5	615.2	200.0	56.0	1600.0	200.0	56.0	1600.0	*200ml*	*8/day*
	mineral water		200.0	29.4	839.1							*200ml*	
	herbal tea, tea, coffee, and substitutes*		29.0	1.0	4.1							*Occasional*	

Table 2 - Serving size, weekly frequency, and daily amount of food groups, subgroups and minor subgroups in the three dietary patterns

* Indicated with different name in Ferrari et al. (15),

**CREA (16, 17),

^ serving size is equal 200g divided 3 times for weeks,

OD = Optimized Diet,

ODp =Optimized Dietary Pattern,

HDp =Healthy Dietary pattern,

Low GHGE_HDp = Low GHGE Healthy Dietary pattern

For the "milk and milk substitute" groups, HDp and Low GHGE_HDp reported a higher daily amount (403.6g and 400.0g, respectively) than ODp (329.9g). In particular, "yoghurt and fermented milk" and "cheese and substitutes" subgroups were major contributors: 125g and 28.6g respectively in HDp, 125g and 24.9g respectively in Low GHGE_HDp vs. 72.6g and 11.6g respectively in ODp. Conversely, higher daily amounts in "potatoes" and "oil and fats" groups were observed in ODp (124.4g and 40.5g respectively) than HDp and Low GHGE_HDp (57.1g and 30.0g, respectively for both patterns). To compare the "pulses" group it was necessary to transform them into the dried form, and the highest daily amount for this group was found in ODp (29.0g).

The daily amount of "beef and veal, not preserved, excl. offal" subgroup was only considered in HDp (7.1g); "Breakfast cereals" only in HDp and Low GHGE_HDp (8.6g). The drinking water in HDp and Low GHGE HDp was reported exclusively as "tap water" (1600 ml in both), while in ODp was reported as "tap water (615.2 ml) and "mineral water" (839.1 ml).

Daily energy, nutrient intakes, and GHGE

The results of the three dietary patterns in terms of GHGE values, energy, and nutrients assumptions with respect to the DRVs suggested by SINU [21] is reported in table 3. HDp was found to be the one with the highest GHGE value ($2.25_{kg\ CO2eq}$ vs. $1.76_{kg\ CO2eq}$ of ODp and $1.67_{kg\ CO2eq}$ of Low GHGE_HDp).

	ODp	HDp	Low GHGE_HDp	DRVs**	
				Males	Females
GHGE (Kg CO_2 eq)	1.76	2.25	1.67		
Total weight of food (g)	2919	3450	3473		
Energy (kcal)	2224	2247	2243		
Water (g)	2415	2906	2933	2500mL(AI)	2000mL(AI)
Protein (g)	75	88	92		
Protein (% En)	13	16	16	12-18% En	
Total fat (g)	74.9	66.4	68.1		
Total fat (% En)	30	27	27	<30% En(RI)	
SFA (% Energy)	9	8	8	<10% En(SDT)	
PUFA (% Energy)	6	6	7	5-10% En(RI)	
Cholesterol (mg)	283	296	281	<300 mg(SDT)	
Available carbohydrate (g)	333	345	335		
Available carbohydrate (% En)	56	57	56	45-60% En(RI)	
Total sugar (g)	78	100	94		
Total sugar (% En)	13	17	16	<15% En(SDT)	
Free sugar*** (g)	28	17	16		
Free sugar*** (% En)	5	3	3	<5 En****	
Fiber (g)	25	32	33	>25 g(SDT)	
Alcohol (g)	0	0	0		

	ODp	HDp	Low GHGE_ HDp	DRVs**	
				Males	Females
Iron (mg)	12	16	16	10 mg(PRI)	10 - 18 mg(PRI)
Calcium (mg)	963	1219	1356	1000-1200 mg(PRI)	
Potassium (g)	3.5	4.4	4.4	3.9 g(AI)	
Zinc (mg)	11	13	14	12 mg(PRI)	9 mg(PRI)
Magnesium (mg)	337	417	429	240 mg(PRI)	
Thiamine / Vit B_1 (mg)	1.3	1.6	1.7	1.2 mg(PRI)	1.1 mg(PRI)
Riboflavin / Vit B_2 (mg)	1.7	2.1	2.4	1.6 mg(PRI)	1.3 mg(PRI)
Pyridoxine/Vit B_6 (mg)	2.1	2.8	2.6	1.3-1.7 mg(PRI)	1.3-1.5 mg(PRI)
Cyanocobalamin/Vit B_{12} (µg)	2.5	5.9	3.9	2.4 µg(PRI)	
Niacin/Vit PP (mg)	17	21	22	18 mg(PRI)	
Ac. Ascorbico/Vit C (mg)	151	205	299	105 mg(PRI)	85 mg(PRI)
Vitamin A (Retinol Eq) (µg)	893	1243	1491	700 µg(PRI)	600 µg(PRI)
Tocopherols / Vit E (mg)	12	12	14	13 mg(AI)	12 mg(AI)

Table 3: *Daily energy and nutrient intakes, GHGE from the Optimized Diet* and the three dietary patterns calculated for a population, 18 - 60 years, and Dietary Reference Values (LARN)**.*

**Ferrari., et al. [15].*

***DRVs: the Dietary Reference Values for energy and macro- and micro-nutrients as defined for Italian by the Levels of Reference Intake of Nutrients and Energy for the Italian Population (LARN) [20],*

****Free sugar was calculated by adding the amount of sugar contained in foods such as biscuits, breakfast cereals, cakes and sweet snacks, savoury fine bakery products. The calculation did not include those categories of foods which, despite containing free sugars, were not considered in the dietary patterns.*

****WHO, 2015 [23],*

AI: Livello di Assunzione Adeguata; AR: Fabbisogno medio; PRI: Assunzione Raccomandata per la popolazione italiana; RI: Intervallo di riferimento per l'assunzione di nutrienti; SDT: Obiettivo nutrizionale di prevenzione,

SFA: Saturated Fatty Acids; PUFA: Polyunsaturated Fatty Acids,

OD = Optimized Diet; ODp =Optimized Dietary Pattern; HDp =Healthy Dietary pattern; Low GHGE_HDp = Low GHGE Healthy Dietary pattern,

n.a.: Data not available in Ferrari., et al. 2020 [15].

Daily Energy ranged from 2224 kcal (ODp) to 2247 kcal (HDp), considering the three dietary patterns. Energy percentage of protein, carbohydrates, and fats were within the DRVs ranges of LARN [20]. Only total sugars in HDp and Low GHEG_HDp were higher than the recommendations (17%En and 16% En respectively), due to intrinsic sugars because, instead, added sugars were lower (3%En in both) [23].

Higher amount of fiber was observed in the HDp and in Low GHGE_HDp (32g and 33g, respectively) vs. 25g of ODp. Higher assumption of iron (although it nearly reached the recommendation for women of childbearing age) was reported in HDp and Low GHGE_HDp (16 mg in both) than ODp (12 mg). Lower-level respect to the recommended range was found in ODp for calcium (963 mg), potassium (3.5g), and zinc (11 mg).

For the vitamins values lower than the DRVs of LARN [21] were not found, except for Niacin in ODp (17 mg) and Tocopherols/Vitamin E (12 mg) in ODp and HDp only for males.

Daily GHGE

Table 4 shows the daily GHGE (kg CO_2eq) values by food groups, subgroups, and smaller subgroups in the three dietary patterns.

GROUPS	SUBGROUPS	MINOR SUBGROUPS	ODp (kg CO_2eq)	HDp (kg CO_2eq)	Low GHGE_HDp (kg CO_2eq)
MILK, MILK PRODUCTS, AND THEIR SUBSTITUTES			***0.520***	***0.750***	***0.655***
	milk, and milk substitutes*		0.321	0.327	0.327
	yoghurt and fermented milk		0.109	0.188	0.188
	cheese, and substitutes		0.090		
		soft cheese, excl. sheep cheese		0.103	0.052
		seasoned cheese, excl. sheep cheese		0.031	0.047
		hard cheese, excl. sheep cheese		0.021	0.042
		sheep cheese (soft and hard)		0.080	
CEREALS, CEREAL PRODUCTS, AND SUBSTITUTES			***0.360***	***0.419***	***0.352***
	bread and flour		0.154	0.149	0.149
	breakfast cereals			0.016	0.016
	pasta with eggs, filled, etc.		0.013	0.029	0.029
	pasta, and pasta substitutes*		0.091	0.055	0.092
	rice		0.027	0.142	0.047
	biscuits		0.054	0.006	0.012
	cake and sweet snacks			0.015	
	savoury fine bakery products		0.021	0.006	0.006
MEAT, MEAT PRODUCTS, AND SUBSTITUTES			***0.078***	***0.190***	***0.106***
	beef & veal, not preserved, excl. offal			0.110	
	pork, not preserved, excl. offal		0.037	0.026	0.052
	poultry and game, not preserved, excl. offal		0.041	0.054	0.054
FISH AND SEAFOOD			***0.049***	***0.199***	***0.127***
	crustaceans, shellfish, mussels			0.125	
	fish, fresh		0.049	0.053	0.105
	fish, preserved			0.022	0.022
PULSES			***0.020***	***0.031***	***0.011***
	pulses, fresh, dried, or processed*		0.020		
		pulses. dried		0.005	0.011
		pulses. fresh		0.025	
EGGS			***0.069***	***0.058***	***0.058***
	eggs		0.069	0.058	0.058
POTATOES			***0.016***	***0.007***	***0.007***
	potatoes, excl. crisps*		0.016	0.007	0.007
FRUIT			***0.079***	***0.337***	***0.155***
	citrus fruits and other fruits, excl. exotic fruits*		0.067	0.117	
		citrus fruits			0.089
		other fresh fruits			0.055
	exotic fruits			0.209	
	nuts, seeds, dried fruits, olives, and their products		0.011	0.011	0.011
	canned fruits				
VEGETABLES			***0.162***	***0.137***	***0.101***
	leafy, fruiting, and other vegetables, fresh		0.151		
		leafy vegetables, fresh		0.009	0.028
		leafy salad		0.026	0.010
		fruiting vegetables, fresh		0.048	0.024
		other vegetables, fresh		0.033	0.017
		mushrooms		0.004	0.006
	roots and onions, fresh		0.006	0.017	0.017
	spices and herbs		0.004		
	vegetables, processed				
OILS & FATS			***0.167***	***0.103***	***0.081***
	olive oil		0.091	0.044	0.037
	other vegetables oil (excl. soyabean oil)*		0.009	0.009	0.017
	butter, cream, and other fats*		0.061	0.032	
		butter			0.010
		cream			
		other fats			
	soyabean oil and soyabean butter*		0.005	0.018	0.018

GROUPS	SUBGROUPS	MINOR SUBGROUPS	ODp (kg CO_2eq)	HDp (kg CO_2eq)	Low GHGE_HDp (kg CO_2eq)
SWEET PRODUCTS AND SUBSTITUTES			***0.055***		
	ice cream, and substitutes		0.023		
	chocolate and substitutes		0.015		
	candies, jam, and other sweet products*		0.004		
	sugar, fructose, honey, and other nutritious sweeteners		0.013		
NON-ALCOHOLIC BEVERAGES			***0.189***	***0.016***	***0.016***
	tap water*		0.006	0.016	0.016
	mineral water		0.176		
	herbal tea, tea, coffee, and substitutes*		0.007		
		Total (kg CO_2eq/day)	**1.764**	**2.247**	**1.669**

Table 4 - Daily GHGE by food groups, subgroups, and minor subgroups in the three dietary patterns

* Indicated with different name in Ferrari *et al*. (15),

OD = Optimized Diet,

ODp =Optimized Dietary Pattern,

HDp =Healthy Dietary pattern,

Low GHGE_HDp = Low GHGE Healthy Dietary pattern

Considering only HDp and Low GHGE_HDp, despite the same or similar daily amount of "fruits" and "vegetable" groups (Table 2), GHGE values resulted lower in Low GHGE_HDp (0.155 for "fruit" and 0.101 for "vegetables") than in HDp (0.337 for "fruits" and 0.137 for "vegetables"). The disparity is to be attributed to the different distribution of the weekly frequencies of serving sizes among minor subgroups (Table 2). The change made to the "fruit" group in Low GHGE_HDp is a clear example that explains what can be modulated to have lower impact respect the HDp. The total of 21 weekly serving sizes recommended for the "fruit" group were equally distributed among the subgroups in HDp. Then the frequency of "exotic fruit" was set to 0 and the related frequencies spread among the minor subgroups (Table S2).

A similar situation was found in the "cereals, cereal products and substitutes" where group lower GHGE values were observed in Low GHGE HDp (0.352) than HDp (0.419) though reporting similar daily amounts (Table 2). The disparity was due to the different weekly frequencies of the serving size of some subgroups such as "rice" (1.5 for Low GHGE HDp vs 4.5 of HDp).

For "meat and meat substitute" group, the difference of GHGE value between HDp (0.190) and Low GHGE HDp (0.106) depended on the choice of serving size of "beef and veal" group as red meat (Table 2).

Finally, GHGE from "non-alcoholic beverages" group was observed higher in ODp (0.189) with respect to HDp and Low GHGE HDp (0.016). The remarked difference was due to choose of considering only "tap water" in the last two dietary patterns.

Figure 1 shows the comparison between the daily amounts of food groups and GHGE (Kg CO_2eq) by the three dietary patterns. It is evident that in most food groups with the same daily amounts, GHGE values of Low GHGE_HDp were lower than HDp. This was due to changing the frequencies among minor subgroups while remaining unchanged those of subgroups as reported by IDG. In fact, in "Milk, milk products, and their substitutes" group GHGE value decreased by 0.095 with exclusion of "sheep cheese" and by halving the "soft cheese" amount; in the "Cereals, cereal products, and substitutes" group, by varying the frequencies between "pasta" and "rice" and excluding "cake and sweet cake" in favor of "biscuits", GHGE dropped by 0.067; in the "Meat, meat products, and substitutes" group, excluding "beef and veal" in favor of "pork", it fell by 0.084; in "fish and seafood" group by excluding "crustaceans, shellfish, mussels" in favor of "fish, fresh" GHGE value decreased by 0.072; in the "fruit" group, excluding "exotic fruit" and increasing "citrus fruit", GHGE value decreased by 0.182; in the "vegetables" group, by decreasing the amount of "fruiting, and other vegetables, fresh" in favor of "leafy vegetables", it decreased by 0.036; by excluding "crème and other fats" in favor of "butter" and increasing "other vegetable oils" and decreasing "olive oil", GHGE value decreased by 0.022.

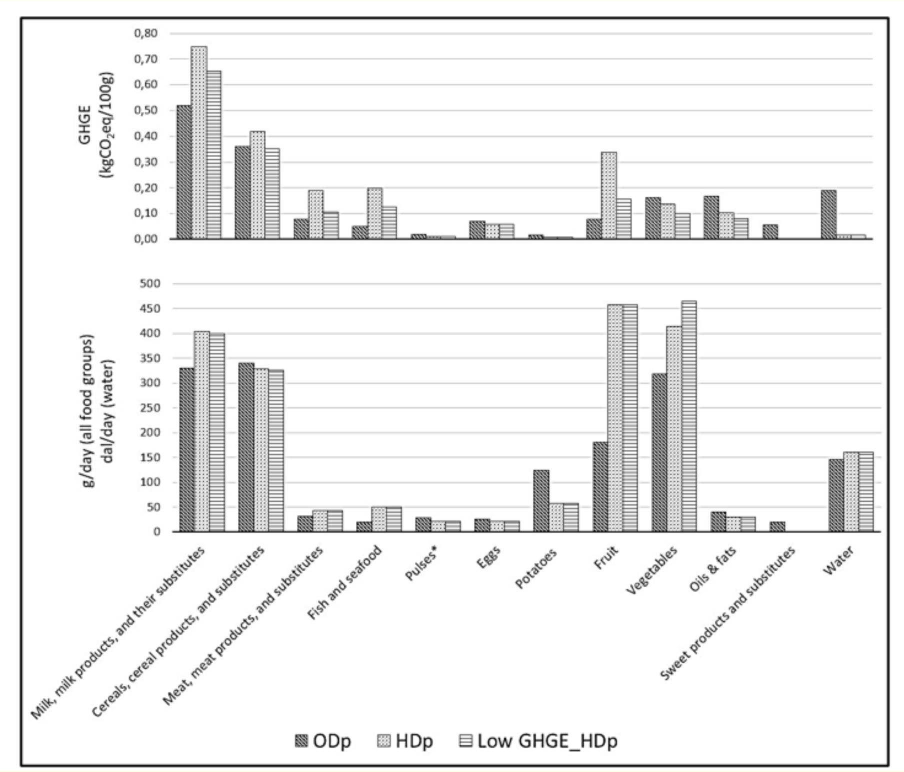

Figure 1: *Comparison between the daily GHGE (kg CO_2eq) and amount of food groups (g) and water (dal) in the three dietary patter. *In HDp the amount of "Pulses" was transformed into the dried form.*

Lower GHGE percentage from the different dietary patterns respect to the GHGE from INCA 1994-96 are reported in table 5. HDp has shown a reduction of 31.9% while ODp of 46.8%. For Low GHGE_HDp the choice of different subgroups and minor subgroups considering their GHGE emission translating into a reduction of 49.4%. To reach the goal of 55%, "2030TargetGHGE_Dp" was formulated and the effect due to the data processing on selected food groups (milk, milk product and their substitute, cereal, cereal products and substitute, fish and seafood and vegetables) is shown in table 6. This was obtained reducing from 21 to 18 the daily serving size frequencies of "milk and yoghurt", removing "pasta with eggs, fillings, etc." and "preserved fish", increasing "leafy vegetable" and representing the subgroup "cheese, and substitutes" only by "seasoned cheese". All the frequencies of removed group were redistributed to the remaining minor subgroups with the constraint to maintain the total frequencies of the food group they belonged to. Nutritional adequacy was however maintained (data not shown in the table) and, in parallel, a further reduction of GHGE from $1.67_{Kg\ CO2eq}$ to $1.49_{Kg\ CO2eq}$, exactly the 55% reduction vs. the baseline assessed in 1994-96 (Table 5).

	1990s*	ODp	HDp	Low GHGE_HDp	2030TargetGHGE_Dp
GHGE (kg CO_2eq/day)	3.3	1.76	2.25	1.67	1.49
Lowering GHGE compared to 1990s (%)		46.8	31.9	49.4	55.0

Table 5: *GHGE and percentage of GHGE lowering of three dietary patterns compared to 1990s*.*
**Turrini [22].*

GROUPS	SUBGROUPS	MINOR SUBGROUPS	Low GHGE_HDp Weekly Frequency (n)	2030TargetGHGE_Dp Serving size (g)	2030TargetGHGE_Dp Weekly Frequency (n)	2030TargetGHGE_Dp Daily amount (g)	2030TargetGHGE_Dp GHGE (kg CO2eq /day)	IDG** *Serving size*	IDG** *Frequency*
MILK, MILK PRODUCTS, AND THEIR SUBSTITUTES						***342.9***	***0.527***		
	milk, and milk substitutes*		14.0	125.0	14	250.0	*0.327*	*125g*	*3/day*
	yoghurt and fermented milk		7.0	125.0	4	71.5	*0.107*		
	cheese, and substitutes								
		soft cheese, excl. sheep cheese	0.5	100.0				*100g*	*3/week*
		seasoned cheese, excl. sheep cheese	1.5	50.0	3	21.4	*0.093*	*50g*	
		hard cheese, excl. sheep cheese	1.0	50.0				*50g*	
		sheep cheese (soft and hard)		50.0				*50g*	
CEREALS, CEREAL PRODUCTS, AND SUBSTITUTES						***316.4***	***0.341***		
	bread and flour		24.5	50.0	24.5	175.0	*0.149*	*50g*	*3.5/day*
	breakfast cereals		2.0	30.0	2.0	8.6	*0.016*	*30g*	*2/week*
	pasta with eggs, filled, etc.		1.5	125.0				*125g*	*1.5/day*
	pasta, and pasta substitutes*		7.5	80.0	9.0	102.9	*0.110*	*80g*	
	rice		1.5	80.0	1.5	17.1	*0.147*	*80g*	
	biscuits		2.0	30.0	2.0	8.6	*0.012*	*30g*	*2/week*
	cake and sweet snacks			50				*50g*	
	savoury fine bakery products		1.0	30.0	1.0	4.3	*0.006*	*30g*	*1/week*
FISH AND SEAFOOD						***48.2***	***0.118***		
	crustaceans, shellfish, mussels			150				*150g*	*2/week*
	fish, fresh		2.0	150.0	2.25	48.2	*0.118*	*150g*	
	fish, preserved		1.0	50.0				*50g*	*1/week*
VEGETABLES						***482.9***	***0.065***		
	leafy, fruiting, and other vegetables, fresh								
		leafy vegetables, fresh	6.5	200.0	7.5	214.3	*0.032*	*200g*	*2.5/day*
		leafy salad	2.0	80.0	1.0	11.4	*0.005*	*80g*	
		fruiting vegetables, fresh	1.0	200.0				*200g*	
		other vegetables, fresh	1.0	200.0				*200g*	
		mushrooms	2.0	200.0	4.0	114.3	*0.011*	*200g*	
	roots and onions, fresh		5.0	200.0	5.0	142.9	*0.017*	*200g*	
	spices and herbs								

Table 6 - Serving size, weekly frequency, daily amount, GHGE of 2030TargetGHGE_Dp, weekly frequency of Low GHGE_HDp, serving size and frequency by Italian Dietary Guidelines**

* Indicated with different name in Ferrari *et al*. (15),

** CREA (16, 17),

Low GHGE_HDp = Low GHGE Healthy Dietary pattern,

2030TargetGHGE_Dp= 2030 Target GHGE Dietary pattern

Daily GHGE values (Kg CO_2eq) from the ODp (1.76 corresponding to 46.6% of GHGE reduction) and from HDp (2.25$_{kg\ CO2eq}$ corresponding to 31.9% of GHGE reduction) did not achieve environmental value target, as the expected decrease was to achieve 1.49$_{kg\ CO2eq}$ for daily food consumption corresponding to 55% of previous GHGE level [23]. The Dutch optimization approach tried to integrate sustainability into FBDGs using the linear and quadratic programming model Optimeal (www.optimeal.info) for the simultaneous optimization of natural and human resources: diet, nutrients, economy, and environment. The authors derived FBDG of the Wheel of Five food-counselling model for a wide range of target groups to help Dutch consumers to make their diets healthier and more environmentally sustainable [9] but without quantitatively indicating the achievement of the GHGE reduction target.

Our results are in line with Broekema., *et al*. [24] which established that GHGE target cannot be reached by only correcting nutritional inadequacy (through a healthy diet) and/or optimizing the diet but additional dietary adjustments are needed. Our study demonstrates that intervening towards the different choices versus food subgroups and minor subgroups with lower GHGE remaining into the daily nutritional recommendations, it was possible to approach more the target although not reach it. In fact, daily GHGE value from Low GHGE HDp resulted lower than ODp and HDp but always higher to the target, i.e. 1.67 corresponding to 49.4% decrease of GHGE. Moving for a sensible shift of Low GHGE HDp and HDp, it was possible to reach the 55% decrease target [22]: weekly frequency of serving size for "milk, milk product and yoghurt and fermented milk" subgroup have been reduced from 21 (considered in the IDG) to 18; "yoghurt" was more chosen than "milk"; without changing the frequencies for "cheese and substitutes" but limiting them to only "seasoned cheese". The EAT-Lancet Commission Reference Diet (ELCRD) [25] consider an average daily amount of "milk and milk product" of 250g (0 - 500g) correspondent to a weekly frequency on 14 serving sizes thus leading our shift in the "milk and yoghurt" frequencies in line with those suggestions that include also cheese as alternative of milk. Indication on changing of other subgroups relative to "pasta with egg", "preserved fish", and "leafy vegetable" are not provided in the Eat Lancet as were left to the free choice to each country, depending on their dietary advice. Thus, it was not possible to analyze the differences. For the other groups and subgroups remained the composition of Low GHGE HDp where our data confirmed how reported by Tucci., *et al*. [26] on the main differences between IDG dietary plan and an Italian-Mediterranean Dietary Pattern Developed Based on the ELCRD [25]: lower amount of fruit and vegetable in ELCRD and in general also for protein source (poultry meat, fish while red meat was comparable), and a higher amount of pulses and nuts. For the comparison of "cereals, cereals products and substitutes", Low HDp suggested 3.5 serving sizes of bread/day (for a total of 175 g/day) and one serving size/day of pasta while ELCRD allowed for bread to a maximum of 300 g/day or cereals twice a day (for a maximum daily amount of 190g). In addition, Low HDP did not consider "cake and sweet snacks" subgroup respect to HDp that included it as one weekly serving size. This changing of indication was in line with the ELCRD that did not include indications related to the intake of sweet bakery products.

Our study shows that to fully reach the 2030 target it is not necessarily moving versus a large shift of the diet i.e. excluding an entire food group but it is enough limiting consumption of red meat, excluding processed meat, moderating the consumption of milk and yoghurt slightly lower than indication of IDG, increasing consumption of pulses, nuts, vegetables and fruit and choosing always "tap water". These results are not in line with a study that reported to satisfy 2050 food system GHGE target is required not only research in consumer preferences but also breakthrough innovations in food production and processing [24]. On the other hand, Vieux., *et al*. [27] reported that exclusion of entire food categories (e.g., meat) is not necessary to improve the sustainability of European diets with the highest GHGE reduction come from the "more sustainable diet" for a value of 21% much lower than that referred to the HDp (31.9%) which contains weekly half serving size of red meat.

An interesting study [28] provided a comparison between the environmental impacts of average observed dietary intake and a national recommended healthy diet across 37 middle- and high-income countries. The authors have found that following a nationally recommended diet in high-income nations results in a reduction in greenhouse gases, eutrophication, and land use. In upper-middle-income nations, they found a smaller reduction in impacts, and in lower-middle-income nations a substantial increase. The net result from large-scale adoption of nationally recommended diets for countries studied here results in a reduction in environmental impacts. On the other hand, healthy and lower GHGE diets could be created in all income quintiles but tailoring changes to income groups to minimise deviation may make more achievable dietary changes.

Worthy of interest is the decrease of the amounts of rice versus "pasta without eggs" in 2030 target Dietary Pattern that leads to consider it low-impact foods in terms of GHGE in the sustainable diet. In fact, some studies report that rice production causes significant global environmental impact. Clune., *et al*. [29] have found that rice has higher GHGE value compared to other plant-based field-grown crops and slightly higher than fruit and vegetables from heated greenhouses ($2.55_{kg\ CO2eq}$/Kg versus $2.13_{kg\ CO2eq}$/Kg). On the other hand, an interesting study [30] proposed to shift Chinese people's eating habit from rice to potato as staple food for the beneficial effect observed for boiled potato respect to rice in both, environmental and nutritional viewpoints. Anyway, the authors recommended that the consumption reduction of rice as staple food it should be gradual. Further attention should be given to rice with more clear environmental implication for the healthy and sustainable consumption.

Taking in consideration the GHGE emissions, the strength of this study is the translation of the" healthy and sustainable diet" as defined by the FAO/WHO [4] into a "practical and adoptable dietary plans by the consumers in terms of serving size, food consumption frequencies and nutritional adequacy". Such dietary patterns, whilst meeting national micronutrients recommendations, tend to be lower in energy dense foods and saturated fat whilst providing higher fibre and fruit and vegetable intakes. It is not surprising that healthy sustainable eating patterns have been associated with improves health outcomes such as reduced risk of obesity and reduced rates of diabetes and heart disease and could result in reductions in total mortality by 6 - 16% [31,32]. Providing indications for the daily and weekly serving size frequencies for each food group and subgroup enables consumers to more friendly approach to adopt a balanced food consumption allowing climate stabilization.

The proposed dietary patterns are addressed directly for the consumers but also for food environment stakeholders such as dieticians to help the public understand what dietary practical changes, they can move to improve both their own health and that of our planet. To be able to reconcile the nutritional and environmental science can give consistent messages about a healthy, sustainable, and varied diet to ensure a sustainable future for food consumption.

The data used in the present study have some limitations. Dietary database is built on food consumption data collected in 2005-06 therefore it could not correctly represent all current food items or composite dishes consumed today. However, it is appropriate to use the same dataset to compare previous results and level obtained by optimizing dietary patterns in a theoretical framework. The optimized dietary patterns can be used as reference values when using other approaches like the data envelopment analysis. It is also acknowledged that there are limitations due to the variability of GHGE estimates provided from different life-cycle assessment (LCA) applied for calculations since no standard GHGE database is provided by country. International guidelines for running LCA, are flexible but do not provide a harmonized LCA database for representative foods available in the marketplace. The application of GHGE data from Ferrari., *et al*. [14] to in the present study to estimate emissions from dietary pattern the percentage reduction target may not provide the exact level. However, the assessed dietary patterns are comparable each other as the same GHGE database was used. Reynolds., *et al*. [11] refer to future research to incorporate global variability of GHGE estimations into linear programming for diet optimization. Another limitation is that the study does not consider the GHGE emissions after the retail phase, such as transport to the household, storing, and cooking as well as waste management. Then, there is a need to implement LCA study with an innovative methodological approach to extend a long-life cycle of food products till to the final consumption at home or outside of home.

Conclusion

Remaining into the recommended frequencies of serving sizes of food groups from IDG, it is possible to approach the target but not fully achieve in the Low GHGE_HDp (1.67 $_{Kg\ CO2eq}$ corresponding to 49.4% of GHGE reduction) lower than HDp but still higher than the goal of 1.49 $_{Kg\ CO2eq}$.

Our results demonstrate that for reaching the 2030 target of the 55% GHGE reduction from daily food consumption, it is not necessary to move versus a large shift of the healthy diet, such as excluding an entire food group, but it is enough efficient changes in the selection of some subgroups choosing among the minor subgroups those with the lowest GHGE, in line with the path indicated by the planetary diet of ELCRD.

Anyway, more robust estimates to evaluate the achievement of 2030 target dietary patterns require to furtherly developing GHGE databases adding values for food chain steps after retails thus considering the ways of food is transported and consumed at home or elsewhere.

Supplementary Material Link

Data Availability Statement

All datasets generated for this study are included in the article/Supplementary Material.

Funding Support

This research was funded by the project SYSTEMIC: "An integrated approach to the challenge of sustainable food systems: adaptive and mitigatory strategies to address climate change and malnutrition" from the Knowledge Hub on Nutrition and Food Security, which has received funding from national research funding parties in Belgium (FWO), France (INRA), Germany (BLE), Italy (MIPAAF), Latvia (IZM), Norway (RCN), Portugal (FCT) and Spain (AEI) in the joint actions of JPI HDHL, JPI-OCEANS and FACCE-JPI, launched in 2019 under ERA-NET ERA-HDHL (No. 696295).

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Bibliography

1. United Nations Framework Convention on Climate Change. "Report of the Conference of the Parties on its twenty-first session", held in Paris from 30 November to 13 December 2015. Addendum. Part two: Action taken by the Conference of the Parties at its twenty-first session (2016).

2. Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') (2021).

3. European Commission. "A Farm to Fork Strategy for a Fair, Healthy and Environmentally Friendly Food System (COM/2020/381)" (2020).

4. Salantă LC., *et al*. "Valuable Food Molecules with Potential Benefits for Human Health". In The Health Benefits of Foods–Current Knowledge and Further Development; Salant,ă, L.C., Edition.; IntechOpen: London, UK (2020).

5. Food and Agriculture Organization of the United Nations and World Health Organization (FAO/WHO). "Sustainable healthy diet - Guiding principles" (2019).

6. Food and Agriculture Organization of the United Nations and World Health Organization (FAO/WHO). "Preparation and Use of Food-Based Dietary Guidelines. Report of a joint FAO/WHO consultation". Geneva: FAO/WHO (1998).

7. Clark M., *et al*. "The Diet, Health, and Environment Trilemma". *Annual Review of Environment and Resources* 43 (2018): 109-134.

8. Ahmed S., *et al*. "Advancing an Integrative Framework to Evaluate Sustainability in National Dietary Guidelines". *Frontiers in Sustainable Food Systems* 3 (2019): 76.

9. Brink E., *et al*. "Development of healthy and sustainable food-based dietary guidelines for the Netherlands". *Public Health Nutrition* 22.13 (2019): 2419-2435.

10. Gonzales Fischer C and Garnet T. "Plates, Pyramids and Planets; Development in National Healthy and Sustainable Dietary Guidelines: A State of Play Assessment". Rome: FAO and Oxford University (2016).

11. Martini D., *et al*. "Principles of Sustainable Healthy Diets in Worldwide Dietary Guidelines: Efforts So Far and Future Perspectives". *Nutrients* 13 (2021): 1827.

12. Reynolds CJ., *et al*. "Healthy and sustainable diets that meet greenhouse gas emission reduction targets and are affordable for different income groups in the UK". *Public Health Nutrition* 22.8 (2019): 1503-1517.

13. Van Dooren C. "A Review of the Use of Linear Programming to Optimize Diets, Nutritiously, Economically and Environmentally". *Frontiers in Nutrition* 21.5 (2018): 48.

14. Kanellopoulos A., *et al*. "Designing healthier and acceptable diets using data envelopment analysis". *Public Health Nutrition* 23.13 (2020): 2290-2302.

15. Ferrari M., *et al*. "Could dietary goals and climate change mitigation be achieved through optimized diet? The experience of modelling the national food consumption data in Italy". *Frontiers in Nutrition* 7 (48) (2020): 1-13.

16. CREA-Centro di Ricerca Alimenti e Nutrizione del Consiglio per la Ricerca in Agricoltura e l'analisi dell'Economia Agraria. "Linee Guida per una Sana Alimentazione". Revisione. Rome, Italy (2018).

17. Rossi L., *et al*. "The 2018 Revision of Italian Dietary Guidelines: Development Process, Novelties, Main Recommendations, and Policy Implications". *Frontiers in Nutrition* 9 (2022): 9.

18. Leclercq C., *et al*. "The Italian National Food Consumption Survey INRAN SCAI 2005-06. Main results in terms of food consumption". *Public Health Nutrition* 12.12 (2009): 2504-2532.

19. Sette S., *et al*. "INRAN-SCAI 2005-6 Study Group. The third Italian national food consumption survey, INRAN-SCAI 2005-06–part 1: Nutrient intakes in Italy". *Nutrition, Metabolism and Cardiovascular Diseases* 21.12 (2011): 922-932.

20. Società Italiana di Nutrizione Umana (SINU). Livelli di Assunzione di Riferimento di Nutrienti ed Energia per la Popolazione Italiana (LARN), IV Revisione. Rome, Italy (2014).

21. European Commission. "2030 Climate Target Plan" (2021).

22. Turrini A., *et al*. "Food consumption patterns in Italy: the INN-CA Study 1994-1996". *European Journal of Clinical Nutrition* 55.7 (2001): 571-588.

23. World Health Organization. "Guideline: Sugars Intake for Adults and Children". WHO: Geneva, Switzerland (2015).

24. Broekema R., *et al*. "Future-proof and sustainable healthy diets based on current eating patterns in the Netherlands". *The American Journal of Clinical Nutrition* 112.5 (2020): 1338-1347.

25. Willett W., *et al*. "Food in the Anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems". *Lancet* 393 (2019): 447-492.

26. Tucci M., *et al*. "An Italian-Mediterranean Dietary Pattern Developed Based on the EAT-Lancet Reference Diet (EAT-IT): A Nutritional Evaluation". *Foods* 10 (2021): 558.

27. Vieux F., *et al*. "More sustainable European diets based on self-selection do not require exclusion of entire categories of food". *Journal of Cleaner Production* 248 (2020).

28. Behrens P., *et al*. "Evaluating the environmental impacts of dietary recommendations". *Proceedings of the National Academy of Sciences (PNAS)* 114.51 (2017): 13412-13417.

29. Clune S., *et al*. "Systematic review of greenhouse gas emissions for different fresh food categories". *Journal of Cleaner Production* 140 (2017): 766-783.

30. Zhongyue X., *et al*. "Comparative evaluation of carbon footprints between rice and potato food considering the characteristic of Chinese diet". *Journal of Cleaner Production* 257 (2020). 257.

31. Biesbroek S., *et al*. "Does a better adherence to dietary guidelines reduce mortality risk and environmental impact in the Dutch sub-cohort of the European Prospective Investigation into Cancer and Nutrition?". *British Journal of Nutrition* 118.1 (2017): 69-80.

32. Aleksandrowicz L., *et al*. "The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health. A Systematic Review". *PLoS One* 11.11 (2016): 10.

Volume 18 Issue 5 May 2023