Dietary Reference Intakes for Sri Lankans

Department of Nutrition
Medical Research Institute
2022

Table of Content

Forward

Good nutrition throughout the lifecycle plays an important role in good health of the individuals. Not only the quantity of the food we eat, but also the quality of the food is vital in maintaining a healthy life. Therefore, it is important to know about the key nutrients in each type of food we eat and the requirement of each key nutrient to maintain a healthy life according to the age, sex and physical activity of the individuals.

The Dietary Reference Intake (DRI) values provide information about the amount of carbohydrate, protein, fat, vitamins and minerals that healthy people need to consume to be healthy. DRI are primarily targeted for healthy individuals with a good body weight according their age and sex.

This DRI book is a useful tool for the medical nutrition field to assess the nutrition requirement and the nutrient intake of the individuals at hospital level. It also can be used to prevent and control the double burden of malnutrition at the community level.

The Department of Nutrition, Medical Research Institute, Sri Lanka has taken a great step to update the Dietary Reference Intake (DRI) values considering it as a current requirement of the country. This book can be used as an essential tool in developing and implementing the policies and guidelines to improve the population's health.

I hope that all the relevant stakeholders will utilize this database in their fields of expertise to ensure the nutritional wellbeing of the general population.

Dr. S.H. Munasinghe
Secretary
Ministry of Health
Sri Lanka

Technical Group

Dr Renuka Jayatissa, Consultant Medical Nutritionist, Head- Department of Nutrition- Medical Research Institute - Colombo

Dr Wasana Marasinghe, Acting Consultant Nutrition Physician, Nutrition Department – Medical Research Institute - Colombo

R. M. Ranbanda, Nutrition Assistant, Nutrition Department – Medical Research Institute - Colombo

Dr Nawamali De Alwis, Medical officer in Nutrition- Nutrition Department – Medical Research Institute - Colombo

Dr Amila G. Perera, Medical officer in Nutrition- Nutrition Department – Medical Research Institute - Colombo

Dr Malika Udagedara, Registrar in Clinical Nutrition, Medical Nutrition Unit - National Hospital Sri Lanka

Dr L. W. Hathurusinghe, Registrar in Clinical Nutrition, Medical Nutrition Unit - National Hospital Sri Lanka

Dr S.B.T Weerasekara, Registrar in Clinical Nutrition, Medical Nutrition Unit - National Hospital Sri Lanka

Dr W M S K W de Alwis, Registrar in Clinical Nutrition, Medical Nutrition Unit - National Hospital Sri Lanka

Dr Lasith Uyanege, Senior Registrar in Clinical Nutrition Medical Nutrition Unit - National Hospital Sri Lanka

Dr Jeewanthi Dissanayake, Registrar in Clinical Nutrition Medical Nutrition Unit - National Hospital Sri Lanka

Dr P.D. Weerasinghe, Senior Registrar in Clinical Nutrition Medical Nutrition Unit - National Hospital Sri Lanka

Dr MMJ Marasinghe, Registrar in Clinical Nutrition – National Hospital Sri Lanka Medical Nutrition Unit - National Hospital Sri Lanka

Acknowledgement

Previous Sri Lankan RDA were published in 2007.

Let us pay our sincere gratitude to the Ministry of Health, Sri Lanka for all the support provided to complete the mission of development of the "Dietary Reference Intake for Sri Lankans". We would like to thank Dr. Asela Gunawardena, Director General of Health Services, Sri Lanka for his immense support given to us to complete this project.

Our deep appreciation goes to Dr. Sudath Dharmarathna, Deputy Director General - Laboratory Services and Dr. H. S. R. Perera, Deputy Director General-Public Health Services (II) for the continuous support given in making this effort a reality.

Furthermore, we would like to acknowledge Dr. Prabhath Amarasinghe, Acting Director and Dr. Jayaruwan Bandara , former Acting Director, MRI, Colombo for administrative support given to us to complete this activity successfully on time.

We truly appreciate the technical panel for supporting us by providing the technical assistance to complete this task.

Last but not least, let us thank all the staff of the Department of Nutrition, MRI for their dedicated work to make this project successful.

Dr. Renuka Jayatissa
Consultant Medical Nutritionist
Head- Department of Nutrition- MRI

Introduction

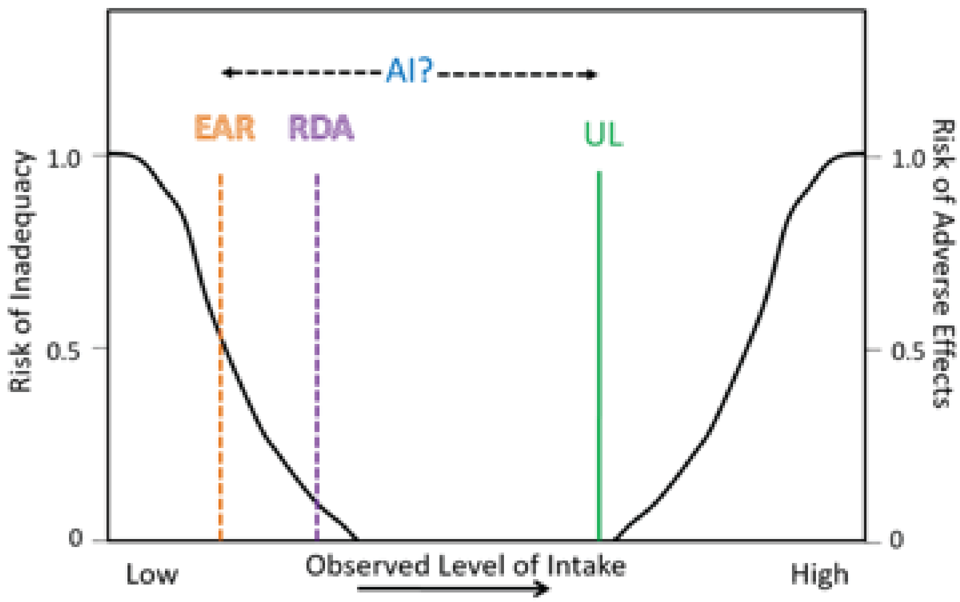
Dietary Reference Intake (DRI) values provide information about the amounts of vitamins, minerals, proteins, carbohydrates and fats that healthy people need to consume to remain healthy. Each essential nutrient has one or more specific physiological functions in the body. The human body either cannot produce or cannot produce them in sufficient quantities. If the intake levels of these vitamins or minerals are too low, symptoms of deficiency may develop and lead to increased risk of disease.

DRI are intended primarily for healthy individuals with a healthy body weight. Level of physical activity, physiological status (such as pregnancy), dietary habits and genetic background are also important factors. Those who suffer from diseases may have different needs and require obtaining guidance from health professionals. However, DRI is also used for chronically ill, older adults or obese individuals due to limited knowledge on the nutritional requirements of these groups.

Many terms are used around the world to describe the daily nutrient intakes required to support human health throughout the life cycle. As shown in Figure 1, there are four types of DRI:

1) the average requirement (EAR / AR),
2) the recommended dietary allowance (RDA),
3) the adequate intake (AI)
4) the tolerable upper intake level (UL).

Figure 1: The types of DRI in relation to the nutrient intake (X axis) and the probability that this intake will be inadequate or too high (Y axis)



Definitions of DRI[1]

AR (Average Requirement)
The average daily nutrient intake that is estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group.

Recommended Dietary Allowance (RDA) / Recommended Intake (RI)/ Recommended Nutrient Intake (RNI) / Recommended Dietary Intake (RDI)
The average daily nutrient intake level that is sufficienct to meet the nutrient requirements of nearly all (97-98 percent) healthy individuals in a particular life stage and gender group. It is derived from the AR. RNI/RDI/RDA = AR +2SDAR.

AI (Adequate Intake) / RI (Reference Intake)
The recommended average daily intake based on observed or experimentally determined approximations or estimates of nutrient intake by a group (groups) of apparently healthy people that are assumed to be adequate. It is used when there is no sufficient data to calculate AR and RDA.

UL (Tolerable Upper intake Level)
The highest average daily nutrient intake at which long-term exposure is not expected to produce any harmful overdosage effects to almost all individuals in the general population. As intake increases above UL, the potential risk of adverse effects increase. The UL does not refer to the acute effects of an episodic high intake due to consumption of supplement.

DRIs are used:

- in dietray assessment and diet planning at individual and population level,
- to set reference values in food labelling and in establishing food based dietary guidelines,
- by food manufacturers for product formulation, and
- for nutrition research.

The recommendations for uses of the various DRI are summarised in the Table 1 as provided by IOM (2000b) and EFSA 2019.

Table 1: Different uses of DRI

Uses	Types of DRI
1. Assessment of adequacy of dietary intakes	
a. For individuals	
I. Enegy based on sex, age, height, weight and physical activity level	AR
II. Protein and micronutrients	RDA or AI/RI
b. For groups	
I. Energy based on sex, age, height, weight and physical activity level of the group	AR
II. Protein and micronutrients	AR or AI/RI
2. In dietary planning	
a. For individuals	
I. Protein, micronutrients	RDA or AI/RI
II. Energy based on sex, age, height, weight and physical activity leveL	AR
b. For groups	
I. Protein, micronutrients	AR or AI/RI
II. Energy based on sex, age, height, weight and physical activity level of the group	AR
3. Food labelling	
I. Convert a nutrient amount in metric units into percentage of daily requirement	RDA

Harmonization of DRI

In 2018, Food and Nutrition Board of Health and Medicine division of National Academics of Sciences, Engineering, and Medicine (NASEM), previous named as IOM and World Health Organization (WHO), convened the expert committee on harmonization of DRI (H-ARs) to establish the globally adoptable new DRI. The proposed global harmonized DRI are based on DRI of the IOM and European Food Safety Authority's (EFSA). For each nutrient, AR, RDA and UL were established, if AR and RDA were not available, AI/RI was included. Considering latest data from EFSA, Sri Lankan DRI was calculated based on EFSA recommendations. When the EFSA data is not available, DRIs were extracted from IOM and Indian RDA table and adjusted accordingly.

Reference body weight

The reference body weights used for the various age/gender groups is provided in Table 2. It was based on following factors.

- WHO growth standards for children 0-18 years were taken considering the use of WHO standards by the Ministry of Health for growth monitoring for that age group.
- The 95th centile of height was taken, for adult male and female, considering full growth potential.
- The reference bodyweight for male and female were estimated from the median weight of male and female population whose height is above 95th percentile and BMI between 20.5 to 21.4 kg/m2 using data of most recent national nutrition survey of Sri Lanka4.
- The standard body weights for all adults were based on 18-95 years olds.

Selection of age groups

Table 2 provides selected age groups, which is adopted from global Harmonized DRI tables (H-ARs).

Adjustments for bioavailability

It was considered that the bioavailability is similar across all diets in the Sri Lankan population, based on mixed diet that people consumed.

- Iron intake was calculated assuming 10% absorption.
- Zinc intake was calculated assuming daily diet provides 900 mg phytate based on mixed semi refined Sri Lankan diet.

PAL values

PAL values of 1.4, 1.7 and 2.0 were taken to approximately reflect low active (sedentary), active and very active lifestyles. Average value of PAL 1.6 and 1.8 was taken as PAL 1.7.

Table 2: Reference body weights of population groups used for calculation

Population Group	Age taken as reference	Reference weight (kg)		
		Males[1]	Females[1]	Both males and females[2]
Infants				
0 - 6 months	3 months	6.4	5.8	6.1
7 - 11 months	9 months	8.9	8.2	8.6
Children				
1 - 3 years	2 years	12.2	11.5	11.9
4 - 6 years	5 years	18.3	18.2	18.3
7 - 10 years	8.5 years	26.5	26.3	26.4
Adolesents[3]				
11 - 14 years	12.5 years	41.1	43.2	42.3
15 - 17 years	16 years	61.3	54.7	58.0
Adults[4]				
18 - 24 years	18-29 years	68.0	57.0	62.5
25 - 50 years	30-49 years	68.0	57.0	62.5
51 - 70 years	50-69 years	68.0	57.0	62.5
>70 years	70-79 years	68.0	57.0	62.5
Pregnancy[5]				
All trimesters	25-50 years	-	69.0	-
Lactation[6]				
First 6 months	25-50 years	-	57.0 +GWGAD	-

[1]The median weight-for-age at the age taken as reference was used as reference weight.
[2]Mean of the values for males and females.
[3]Derived from WHO standarad tables of BMI-for-age and Height-for-age of 10-17 years. The median height-for-age and meadin BMI-for-age at the age taken as reference was used to calculate reference weight for males and females.
[4]Derived from measured body heights of men and women aged 18-95 years in Sri Lanka and assuming a body mass index between 20.5 - 21.5 kg/m^2.
[5]Pregnancy weight = adult women + (GWG - Gestational Weight Gain = 12 kg).
[6]Lactation weight = adult women + GWGAD (Gestational Weight Gain remaining After Delivery)

TABLE 1: Daily Average Requirement (AR) for energy, protein, vitamins and minerals

Life stage	Age	Sex	Activity level	Mean weight kg	Energy kcal	Protein g	Vit A µg RAE	Vit C mg	Thiamine mg	Niacin mg	Riboflavin mg	Vit B_6 mg	Folate µg DFE	Calcium	Iron	Zinc
Infants	0-6 month	Both	-	6.1	530	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	7-11 month	Both	-	8.6	660	10	190	NA	0.3	3.6	*0.4	*0.3	*80	*280	8	2.4
Children	1-3 year	Both	-	11.9	990	9	205	15	0.4	5.4	0.5	0.5	90	390	6	3.6
	4-6 year	Both	Sedentary	18.3	1290	13	245	25	0.5	7.0	0.6	0.6	110	450	8	4.6
			Active		1560	13	245	25	0.5	8.5	0.6	0.6	110	450	8	4.6
	7-10 year	Both	Sedentary	26.4	1580	20	320	40	0.6	8.6	0.8	0.9	160	500	10	6.2
			Active		1920	20	320	40	0.6	10.4	0.8	0.9	160	500	10	6.2
	11-14 year	Male	Active	41.1	2390	30	480	60	1.0	13.0	1.1	1.2	210	800	14	8.9
			Very active		2820	30	480	60	1.1	15.3	1.1	1.2	210	800	14	8.9
		Female	Active	43.2	2180	31	480	60	1.1	11.9	1.1	1.2	210	800	17	8.9
4			Very active		2570	31	480	60	0.9	14.0	1.1	1.2	210	800	17	8.9
	15-17 year	Male	Active	61.3	3020	44	580	85	1.2	16.4	1.4	1.5	250	850	18	11.8
			Very active		3560	44	580	85	1.4	19.4	1.4	1.5	250	850	18	11.8
		Female	Active	54.7	2400	37	490	75	1.0	13.1	1.4	1.3	250	850	18	9.9
			Very active		2820	37	490	75	1.1	15.3	1.4	1.3	250	850	18	9.9
Adults	18-24 year	Male	Sedentary	68.0	2340	45	570	90	0.9	12.9	1.3	1.5	250	860	11	11
			Active		2840	45	570	90	1.1	15.6	1.3	1.5	250	860	11	11
			Very active		3340	45	570	90	1.3	18.4	1.3	1.5	250	860	11	11
		Female	Sedentary	57.0	1890	38	490	80	0.8	10.4	1.3	1.3	250	860	15	8.9
			Active		2280	38	490	80	0.9	12.5	1.3	1.3	250	860	15	8.9
			Very active		2680	38	490	80	1.1	14.7	1.3	1.3	250	860	15	8.9
	25-50 year	Male	Sedentary	68.0	2250	45	570	90	0.9	12.4	1.3	1.5	250	750	11	11
			Active		2930	45	570	90	1.2	16.1	1.3	1.5	250	750	11	11
			Very active		3210	45	570	90	1.3	17.7	1.3	1.5	250	750	11	11
		Female	Sedentary	57.0	1800	38	490	80	0.7	9.9	1.3	1.3	250	750	15	8.9
			Active		2170	38	490	80	0.9	11.9	1.3	1.3	250	750	15	8.9
			Very active		2570	38	490	80	1.0	14.1	1.3	1.3	250	750	15	8.9
	51-70 year	Male	Sedentary	68.0	2100	45	570	90	0.8	11.6	1.3	1.5	250	750	11	11
			Active		2560	45	570	90	1.0	14.1	1.3	1.5	250	750	11	11
			Very active		3020	45	570	90	1.2	16.6	1.3	1.5	250	750	11	11
		Female	Sedentary	57.0	1710	38	490	80	0.7	9.4	1.3	1.3	250	750	15	8.9
			Active		2070	38	490	80	0.8	11.4	1.3	1.3	250	750	15	8.9
			Very active		2440	38	490	80	1.0	13.4	1.3	1.3	250	750	15	8.9
	>70 year	Male	Sedentary	68.0	1980	45	570	90	0.8	10.9	1.3	1.5	250	750	11	11

Life stage	Age	Sex	Activity level	Mean weight kg	Energy kcal	Protein g	Vit A µg RAE	Vit C mg	Thiamine mg	Niacin mg	Ribofla-vin mg	Vit B_6 mg	Folate µg DFE	Calcium	Iron	Zinc
			Active		2410	45	570	90	1.0	13.3	1.3	1.5	250	750	11	11
			Very active		2840	45	570	90	1.1	15.6	1.3	1.5	250	750	11	11
		Female	Sedentary	57.0	1620	38	490	80	0.6	8.9	1.3	1.3	250	750	15	8.9
			Active		1960	38	490	80	0.8	10.8	1.3	1.3	250	750	15	8.9
			Very active		2290	38	490	80	0.9	12.6	1.3	1.3	250	750	15	8.9
Pregnancy	1st Trimester	Female	Sedentary	69.0	1960	38	540	90	0.8	10.8	1.5	1.5	*600	750	21	10.2
	2nd Trimester	Female	Sedentary		2150	45	540	110	0.9	11.8	1.5	1.5	*600	750	21	10.2
	3rd Trimester	Female	Sedentary		2390	61	540	110	1.0	13.1	1.5	1.5	*600	750	21	10.2
Lactation	0-6 Postpartum	Female	Sedentary	-	2390	53	1020	140	1.0	13.1	1.7	1.4	380	750	16	11.3

(*AI)

TABLE 2: Adequate Intake (AI) for vitamins

Life stage	Age	Sex	PAL	Vit D µg	Vit E as α-tocopherol mg	Vit B_{12} µg	Vit K µg	Pantothenic acid mg	Biotin mg	Choline mg
Infants	0-6 month	All	All							
	7-11 month	All	All	10	5	1.5	10	3.0	6	160
Children	1-3 year	All	All	15	6	1.5	12	4.0	20	140
	4-6 year	All	All	15	9	1.5	20	4.0	25	170
	7-10 year	All	All	15	9	2.5	30	4.0	25	250
	11-14 year	All	All	15	13	3.5	45	5.0	35	340
				15	11	3.5	45	5.0	35	340
	15-17 year	M	All	15	13	4.0	65	5.0	35	400
		F	All	15	11	4.0	65	5.0	35	400
Adults	≥ 18 year	M	All	15	13	4.0	70	5.0	40	400
		F	All	15	11	4.0	70	5.0	40	400
Pregnancy	All trimester	F	All	15	11	4.5	70	5.0	40	480
Lactation	0-6 PP	F	All	15	11	5.0	70	7.0	45	520

TABLE 3: Adequate Intake (AI) for minerals

Life stage	Age	Sex	PAL	Chlo-ride mg	Copp-er mg	Flori-de mg	Mag-nesium mg	Man-ganese mg	Phop-horos mg	Potas-sium mg	Selen-ium µg	Moly-bden-um µg	Iodine µg	Sodium g
Infants	0-6 month	B	All											
	7-11 month	B	All	0.3	0.4	0.4	80	0.02-0.5	160	750	15	10	70	0.2
Children	1-3 year	B	All	1.7	0.7	0.6	170	0.5	250	800	15	15	90	1.1
	4-6 year	M	All	2.0	1.0	1.0	230	1.0	440	1100	20	20	90	1.3
		F	All	2.0	1.0	0.9	230	1.0	440	1100	20	20	90	1.3
	7-10 year	M	All	2.6	1.0	1.5	230	1.5	440	1800	35	30	90	1.7
		F	All	2.6	1.0	1.4	230	1.5	440	1800	35	30	90	1.7
	11-14 year	M	All	3.1	1.3	2.2	230	2.0	640	2700	55	45	120	2.0
		F	All	3.1	1.1	2.3	230	2.0	640	2700	55	45	120	2.0
	15-17 year	M	All	3.1	1.3	3.2	300	3.0	640	3500	70	65	130	2.0
		F	All	3.1	1.1	2.8	250	3.0	640	3500	70	65	130	2.0
Adults	≥ 18 year	M	All	3.1	1.6	3.4	350	3.0	550	3500	70	65	150	2.0
		F	All	3.1	1.3	2.9	300	3.0	550	3500	70	65	150	2.0
Pregnancy	All T	F	All	3.1	1.5	2.9	300	3.0	550	3500	70	65	200	2.0
Lactation	0-6 PP	F	All	3.1	1.5	2.9	300	3.0	550	4000	85	65	200	2.0

TABLE 4: Daily Recommended Dietary Allowance (RDA) for energy, protein, vitamins and minerals

Life stage	Age	Sex	Activity level	Mean weight kg	Energy kcal	Protein g	Vit A µg RAE	Vit C mg	Thiamine mg	Niacin mg	Ribofla-vin mg	Vit B_6 mg	Folate µg DFE	Calcium	Iron	Zinc
Infants	0-6 month	Both	-	6.1	530	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	7-11 month	Both	-	8.6	660	11	250	20	0.3	4.4	*0.4	*0.3	*80	*280	11	2.9
Children	1-3 year	Both	-	11.9	990	12	250	20	0.4	6.6	0.6	0.6	120	450	8	4.3
	4-6 year	Both	Sedentary	18.3	1290	16	300	30	0.5	8.5	0.7	0.7	140	550	11	5.5
			Active		1560	16	300	30	0.7	10.3	0.7	0.7	140	550	11	5.5
	7-10 year	Both	Sedentary	26.4	1580	24	400	45	0.7	10.4	1.0	1.0	200	650	15	7.4
			Active		1920	24	400	45	0.8	12.7	1.4	1.0	200	650	15	7.4
	11-14 year	Male	Active	41.1	2390	37	600	70	1.0	15.8	1.4	1.4	270	1000	17	10.7
			Very active		2820	37	600	70	1.2	18.6	1.4	1.4	270	1000	17	10.7
		Female	Active	43.2	2180	38	600	70	0.9	14.4	1.4	1.4	270	1000	30	10.7
4			Very active		2570	38	600	70	1.1	17.0	1.4	1.4	270	1000	30	10.7
	15-17 year	Male	Active	61.3	3020	53	750	100	1.3	19.9	1.6	1.7	330	1050	26	14.2
			Very active		3560	53	750	100	1.5	23.5	1.6	1.7	330	1050	26	14.2
		Female	Active	54.7	2400	46	650	90	1.0	15.8	1.6	1.6	330	1050	32	11.9
			Very active		2820	46	650	90	1.2	18.6	1.6	1.6	330	1050	32	11.9
Adults	18-24 year	Male	Sedentary	68.0	2340	56	750	110	1.0	15.4	1.6	1.7	330	1000	19	14.0
			Active		2840	56	750	110	1.2	18.7	1.6	1.7	330	1000	19	14.0
			Very active		3340	56	750	110	1.4	22.0	1.6	1.7	330	1000	19	14.0
		Female	Sedentary	57.0	1890	47	650	95	0.8	12.5	1.6	1.6	330	1000	29	11.0
			Active		2280	47	650	95	1.0	15.0	1.6	1.6	330	1000	29	11.0
			Very active		2680	47	650	95	1.1	17.7	1.6	1.6	330	1000	29	11.0
	25-50 year	Male	Sedentary	68.0	2250	56	750	110	0.9	14.9	1.6	1.7	330	950	19	14.0
			Active		2930	56	750	110	1.2	19.3	1.6	1.7	330	950	19	14.0
			Very active		3210	56	750	110	1.3	21.2	1.6	1.7	330	950	19	14.0
		Female	Sedentary	57.0	1800	47	650	95	0.8	11.9	1.6	1.6	330	950	29	11.0
			Active		2170	47	650	95	0.9	14.3	1.6	1.6	330	950	29	11.0
			Very active		2570	47	650	95	1.1	17.0	1.6	1.6	330	950	29	11.0
	51-70 year	Male	Sedentary	68.0	2100	56	750	110	0.9	13.9	1.6	1.7	330	950	19	14.0
			Active		2560	56	750	110	1.1	16.9	1.6	1.7	330	950	19	14.0
			Very active		3020	56	750	110	1.3	19.9	1.6	1.7	330	950	19	14.0
		Female	Sedentary	57.0	1710	47	650	95	0.7	11.3	1.6	1.6	330	950	29	11.0
			Active		2070	47	650	95	0.9	13.7	1.6	1.6	330	950	29	11.0
			Very active		2440	47	650	95	1.0	16.1	1.6	1.6	330	950	29	11.0
	>70 year	Male	Sedentary	68.0	1980	56	750	110	0.8	13.1	1.6	1.7	330	950	19	14.0
			Active		2410	56	750	110	1.0	15.9	1.6	1.7	330	950	19	14.0

Life stage	Age	Sex	Activity level	Mean weight kg	Energy kcal	Protein g	Vit A µg RAE	Vit C mg	Thiamine mg	Niacin mg	Ribofla-vin mg	Vit B_6 mg	Folate µg DFE	Calcium	Iron	Zinc
			Very active		2840	56	750	110	1.2	18.7	1.6	1.7	330	950	19	14.0
		Female	Sedentary	57.0	1620	47	650	95	0.7	10.7	1.6	1.6	330	950	29	11.0
			Active		1960	47	650	95	0.8	12.9	1.6	1.6	330	950	29	11.0
			Very active		2290	47	650	95	1.0	15.1	1.6	1.6	330	950	29	11.0
Pregnancy	1st Trimester	Female	Sedentary	69.0	1960	48	700	105	0.8	12.9	1.9	1.8	*600	950	27	10.2
	2nd Trimester	Female	Sedentary		2150	55	700	105	0.9	14.2	1.9	1.8	*600	950	27	10.2
	3rd Trimester	Female	Sedentary		2390	70	700	105	1.0	15.8	1.9	1.8	*600	950	27	10.2
Lactation	0-6 Postpartum	Female	Sedentary	-	2390	62	1300	155	1.0	15.8	2.0	1.7	500	950	23	11.3

(*AI)

TABLE 5: Daily Tolerable Upper Intake (UL) for protein and vitamins

Life stage	Age	Sex	Protein P/E ratio	Vit A µg RAE	Vit C mg	Thiamine mg	Niacin mg	Ribofla-vin mg	Vit B_6 mg	Folate µg DFE	Vit D µg	Vit E as α-tocopherol mg	Vit B_{12} µg	Vit K µg	Pantothenic acid mg	Biotin mg	Choline g
Infants	0-6 month	Both	<15%			ND	ND	ND		ND			ND		ND	ND	NA
	7-11 month	Both	<15%	ND	ND	ND	150 Ni 2 NA	ND	ND	ND	35	ND	ND	ND	ND	ND	NA
Children	1-3 year	Both	<15%	800	350	ND	150 Ni 2 NA	ND	5	200	50	100	ND	ND	ND	ND	NA
	4-6 year	Both	<15%	1100	550	ND	220 Ni 3 NA	ND	7	300	50	120	ND	ND	ND	ND	NA
	7-10 year	Both	<15%	1500	800	ND	350 Ni 4 NA	ND	10	400	50	160	ND	ND	ND	ND	NA
	11-14 year	Male	<15%	2000	1050	ND	500 Ni 6 NA	ND	15	600	100	220	ND	ND	ND	ND	NA
		Female	<15%	2000	1300	ND	500 Ni 6 NA	ND	15	600	100	220	ND	ND	ND	ND	NA
	15-17 year	Both	<15%	2600	1550	ND	700 Ni 8 NA	ND	20	800	100	260	ND	ND	ND	ND	NA
Adults	≥ 18 year	Both	<40%	3000	2000	ND	900 Ni 10 NA	ND	25	1000	100	300	ND	ND	ND	ND	NA
Pregnancy	All Trimester	Female	<30%	3000	2000	ND	ND	ND	25	1000	100	300	ND	ND	ND	ND	NA
Lactation	0-6 Postpartum	Female	<40%	3000	2000	ND	ND	ND	25	1000	100	300	ND	ND	ND	ND	NA

(*AI; NI-Nicotinamide, NA-Nicotinic acid, ND-Not Developed, NA-Not Available)

TABLE 6: Daily Tolerable Upper Intake (UL) for minerals

Life stage	Age	Sex	Calcium mg	Iron	Zinc	Chlo-ride mg	Copper mg	Flori-de mg	Mag-nesium mg	Man-ganese mg	Phop-horos mg	Potas-sium mg	Selen-ium µg	Moly-bden-um µg	Iodine µg	Sodium g
Infants	0-6 month	Both														
	7-11 month	Both	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
Children	1-3 year	Both	ND	ND	7	NA	1	1.5	ND	ND	ND	ND	60	0.1	200	NA
	4-6 year	Both	ND	ND	10	NA	2	2.5	250	ND	ND	ND	90	0.2	250	NA
	7-10 year	Both	ND	ND	13	NA	3	2.5	250	ND	ND	ND	130	0.25	300	NA
	11-14 year	Both	ND	ND	18	NA	4	5.0	250	ND	ND	ND	200	0.4	450	NA
	15-17 year	Both	ND	ND	22	NA	4	7.0	250	ND	ND	ND	250	0.5	500	NA
Adults	≥ 18 year	Both	2500	ND	25	NA	5	7.0	250	ND	ND	ND	300	0.6	600	NA
Pregnancy	All Trimester	Female	2500	ND	25	NA	ND	7.0	250	ND	ND	ND	300	0.6	600	NA
Lactation	0-6 Postpartum	Female	2500	ND	25	NA	ND	7.0	250	ND	ND	ND	300	0.6	600	NA

(*AI)

1) Energy

EFSA recommendations were used after adjusting the reference weight of Sri Lankans. Total Energy Expenditure (TEE) is predicted as Resting Enegry Expenditure (REE) x Physical Activity Level (PAL). REE was estimated using predictive equations of Henry (2005) and Schofield et al (1985) for healthy adults, children and adolesents. After calculating the energy, it was approximated for ten digit to make it user friendly. (Table 1.1)

Details are provided below.

Life stage	TEE was based on
Infants 0 - 6 months of age	Energy supply from breast milk.
Infants 7 - 11 months of age	TEE + Energy needs for growth.
1 - 17 years of age	Predictive REE and adjusted PAL for growth. PAL values of 1.4, 1.7 and 2.0 were used.
18 - 29 years of age	Predictive equations of Henry (2005) were used to estimate REE. PAL values of 1.4, 1.7 and 2.0 were taken to reflect low active (sedentary), active and very active lifestyles. Average of 1.6 and 1.8 PAL was taken as 1.7 PAL.
Pregnant women	A mean gestational increase in body mass of 12 kg was considered to be associted with optimal maternal and fetal health outcomes. The average additional energy expenditure in each trimester was taken as: • First Trimester – 70 kcal/day • Second Trimester – 260 kcal/day • Third Trimester – 500 kcal/day
Lactation women	An additional 500 kcal/day was considered predicting exclusively breatfeeding during the first six months after birth. No additional energy requirement was considered beyond six months.

TABLE 1.1: AR for Energy kcal

Life stage	Age	Sex	PAL values	Kcal/ kg/d	AR Energy kcal /mean wt
Infants	0 - 6 months	Both	-	-	-
	7 - 11 months	Both	-	77	660
Children	1 - 3 years	Both	-	83	990
	4 - 6 years	Both	Sedentary	70	1290
			Active	85	1560
	7 - 10 years	Both	Sedentary	60	1580
			Active	73	1920
	11 - 14 years	Male	Active	58	2390
			Very active	69	2820
		Female	Active	50	2180
			Very active	59	2570
	15 - 17 years	Male	Active	49	3020
			Very active	58	3560
		Female	Active	44	2400
			Very active	52	2820
Adults	18 - 24 years	Male	Sedentary	34	2340
			Active	42	2840
			Very active	49	3340
		Female	Sedentary	33	1890
			Active	40	2280
			Very active	47	2680
	25 - 50 years	Male	Sedentary	33	2250
			Active	43	2930
			Very active	47	3210
		Female	Sedentary	32	1800
			Active	38	2170
			Very active	45	2570
	51 - 70 years	Male	Sedentary	31	2100
			Active	38	2560
			Very active	44	3020
		Female	Sedentary	30	1710
			Active	36	2070
			Very active	42	2440
	> 70 years	Male	Sedentary	29	1980
			Active	35	2410
			Very active	42	2840
		Female	Sedentary	28	1620
			Active	34	1960
			Very active	40	2290
Pregnancy	First Trimester	Female	Sedentary	28	1960
	Second Trimester	Female	Sedentary	32	2150
	Third Trimester	Female	Sedentary	35	2390
Lactation	First 6 months	Female	Sedentary	35	2390

2) Carbohydrates And Dietary Fibre

There are two categories of carbohydrates.

I. Glycaemic (digestible) carbohydrates

It includes carbohydrate digested and absorbed in the small intestine. They are sugars (monosaccharides and disaccharides), malto-oligosaccharides, and starch.

II. Dietary fibre

It includes non-digestible carbohydrates passing to the large intestine. They are Lignin, cellulose, hemicelluloses, pectins, hydrocolloids, resistant oligosaccharides (fructo-oligosaccharides (FOS), galactooligosaccharides (GOS), other resistant oligosaccharides) and resistant starch.
EFSA recommendations were adopted (Table 2.1).

Table 2.1: Reference Intakes (RIs) for total carbohydrates and dietary fibre

Age group	Gender	Total carbohydrates (% of energy intake)	Dietary fibre (g/day)
7 – 11 months	Both	*40	-
1 – 3 years	Both	45 - 60	10
4 - 6 years	Both	45 - 60	14
7 - 10 years	Both	45 - 60	16
11 - 14 years	Both	45 - 60	19
15 - 17 years	Both	45 - 60	21
≥ 18 years	Both	45 - 60	25

(*AI)

3) Total Fat & Fatty Acids

Dietary fats (lipids) include triacylglycerols, phosphatidylcholine and cholesterol. Fatty acids are classified according to their number of double bonds. Saturated fatty acids (SFA) have no double bonds, while monounsaturated fatty acids (MUFA) have one double bond and polyunsaturated fatty acids (PUFA) have two or more double bonds. These double bonds can have either the cis or trans configuration. Recommendations are based on recent EFSA values and provided in Table 3.1. Recommendations are expressed as percentage of total dietary energy (E%) or as mg per day.

Table 3.1: Reference Intakes (RI)[1] for total fat and Adequate Intakes (AI)[2] for fatty acids

Age group	Total fat (E%)[1,2]	SFA	LA (E%)	ALA (E%)	EPA+DHA (mg/day)	TFA
7 - 11 months2	*40	ALAP	4	0.5	100 DHA	ALAP
1 - 3 year	35 - 40	ALAP	4	0.5	250 EPA+DHA	ALAP
4 - 6 year	20 - 35	ALAP	4	0.5	250 EPA+DHA	ALAP
7 - 10 year	20 - 35	ALAP	4	0.5	250 EPA+DHA	ALAP
11 - 14 year	20 - 35	ALAP	4	0.5	250 EPA+DHA	ALAP
15 - 17 year	20 - 35	ALAP	4	0.5	250 EPA+DHA	ALAP
≥ 18 year	20 - 35	ALAP	4	0.5	250 EPA+DHA	ALAP
Pregnancy	20 - 35	ALAP	4	0.5	+ 100-200 DHA	ALAP
Lactation	20 - 35	ALAP	4	0.5	+ 100-200 DHA	ALAP

ALA - α-linolenic acid; DHA - docosahexaenoic acid; EPA - eicosapentaenoic acid; LA - linoleic acid; SFA - saturated fatty acids; TFA - trans-fatty acids;
E% - percentage of energy intake; ALAP - as low as possible; *(AI)

Polyunsaturated fatty acids are subdivided into n-6 polyunsaturated fatty acids (n-6 PUFA), n-3 polyunsaturated fatty acids (N-3 PUFA), and n-3 long-chain polyunsaturated fatty acids (n-3 LCPUFA).

n-6 PUFA
Linoleic acid (LA) is an Essential Fatty Acid (EFA), which cannot be synthesised by the body. It is required to maintain metabolic integrity. Arachidonic acid (ARA) is not an EFA, which is synthesised by the body from linoleic acid.

n-3 PUFA
Alpha-linoleic acid (ALA) is an Essential Fatty Acid (EFA), which cannot be synthesised by the body. It is also required to maintain metabolic integrity. Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are not an EFA, which is synthesised by the body from ALA.

Trans fatty acids (TFA)
TFA are not synthesised by the body and are not required in the diet.

Cholesterol
Cholesterol does not provide energy but plays a central role in many metabolic processes.

4) Protein

The protein requirement includes both total nitrogen and indispensable amino acid requirements. Globally harmonized AR values are based on nitrogen balance studies and growth requirements of children. An additional protein intake during pregnancy and lactation is also considered according to EFSA recommendation. UL was taken from ICMR-NIN-2020 tables. The average daily protein requirements for various age groups are expressed as gram/kg body weight/day (Table 4.1).

Table 4.1: ARs, RDAs and UL for protein (g/kg body weight/day)

Life stage	Age	Sex	AR grams	RDA grams	UL (PE ratio)
Infants	0 - 6 months	Both	-	1.13	<15%
	7 - 11 months	Both	1.12	1.31	<15%
Children	1 - 3 years	Both	0.79	0.97	<15%
	4 - 6 years	Both	0.69	0.85	<15%
	7 - 10 years	Both	0.75	0.92	<15%
	11 - 14 years	Male	0.73	0.9	<15%
		Female	0.71	0.89	<15%
	15 - 17 years	Male	0.71	0.87	<15%
		Female	0.68	0.84	<15%
Adults	18 - 24 years	Male	0.66	0.83	<40%
		Female	0.66	0.83	<40%
	25 - 50 years	Male	0.66	0.83	<40%
		Female	0.66	0.83	<40%
	51 - 70 years	Male	0.66	0.83	<40%
		Female	0.66	0.83	<40%
	> 70 years	Male	0.66	0.83	<40%
		Female	0.66	0.83	<40%
Pregnancy	1st trimester		+0.52 g/d[1]	+1 g/d[2]	<30%
	2nd trimester		+7.2 g/d[1]	+9 g/d[2]	<30%
	3rd trimester		+23.0 g/d[1]	+28 g/d[2]	<30%
Lactation	0 - 6 months PP		+15.0 g/d[1]	+19 g/d[2]	<40%
	> 6 months PP		+10.0 g/d[1]	+13 g/d[2]	<40%

(PE ratio – Protein Energy ratio)

EFSA recommended values of 0.5 years for 0-6 months, RDA of 1 year for 7-11 months and averages for other age groups were taken.
[1]in addition to the AR for protein of non-pregnant, nonlactating women.
[2]in addition to the RDA for protein of non-pregnant, non-lactating women

All these DRIs are based on high-biological value proteins. When intakes of protein of poorer quality, it should be adjusted before calculating the prevalence of inadequacy. It is recommended to use FAO/WHO (2011), Digestible essential Amino Acid Score (DIAAS) to adjust the protein quality. However, it is not needed to adjust protein quality when the protein intake is > 100%.

DIAAS is defined as: DIAAS % = 100 x [(mg of digestible dietary indispensable amino acid in 1 g of the dietary protein) / (mg of the same dietary indispensable amino acid in 1 g of the reference protein)]. In the calculation of DIAAS, FAO/WHO recommended it should be based on true ileal digestibility values of individual amino acids rather than the overall (faecal) digestibility of protein.

FAO/WHO (2011) recommended amino acid scoring patterns for calculating protein quality for dietary assessment is provided in Table 4.2. It is expressed as amino acid mg per gram of protein. It identifies the adequacy or deficiency in each amino acid. These scores are based on,

- Infants (birth to 6 months) - pattern of breast milk.
- Young children (6 months to 3 years) - pattern for the 0.5-year-old infant.
- Older children, adolescents and adults - pattern for the 3- to 10-year-old child.
- For regulatory purposes
    - o infant formulas - the amino acid composition of human milk
    - o all other foods and population groups - the pattern for young children aged 6 months to 3 years.

Table 4.2: FAO/WHO Recommended amino acid scoring patterns for infants, children and older children, adolescents and adults

Age Group	Amino acid scoring pattern in mg / protein requirement in grams								
	His	Ile	Leu	Lys	SAA	AAA	Thr	Trp	Val
Infant (Birth-6 months)	21	55	96	69	33	94	44	17	55
Child (6 months-3 year)	20	32	66	57	27	52	31	8.5	43
Older child, adolescent, adult	16	30	61	48	23	41	25	6.6	40

His-histidine; Ile-isoleucine; Leu-leucine; Lys-lysine;
SAA-Sulphur Amino Acid (methionine+cystine);
AAA-Aromatic Amino Acids(phenylalanine+tyrosine);
Thr-threonine; Trp-tryptophan; Val-valine;

Table 4.3 shows Protein rich food sources.

Table 4.3: Protein rich food sources

Food name	Protein content (g)/100 g	Serving size	Protein content/serving (g)
Skimmed cow's milk powder	37.6	30g	11.3
Skipjack tuna (Dried)	63.8	15g	9.6
Maldives fish	61.3	15g	9.2
Whole egg	13.6	60g	8.2
Whole cow's milk powder	26.6	30g	8.0
Anchovy sprats	51.2	15g	7.7
Tuna mackerel fish	24.5	30g	7.4
Pistachio nut	23.6	30g	7.1
Beef chops	23.3	30g	7.0
Skinless broiler chicken breast	23.1	30g	6.9
Country chicken breast with skin	22.1	30g	6.6
Seer fish	22.2	30g	6.7
Ground nut	22.4	30g	6.7
Green gram, dhal	23.4	20g(raw), 3TBS (cooked)	4.68
Lentil, dhal	23.1	20g(raw), 3TBS (cooked)	4.62
White cowpea	21.3	20g(raw), 3TBS (cooked)	4.26

5) Water

Water is consumed from different sources, which include drinking water (tap and bottled water), beverages, moisture content of foods, and water produced by oxidative processes in the body. Water intake from beverages and foods is defined as total water intake, while the sum of total water intake and oxidation water constitutes total available water. EFSA recommendation was adopted to calculate the adequate intake of water for Sri Lankans as shown in Table 5.1.

These adequate intakes were recommended by EFSA considering following factors:

- Moderate environmental temperature and moderate physical activity levels of 1.6 PAL.
- Water losses under extreme conditions of high external temperature and physical exercise are estimated up to about 8,000 mL / day.
- Replacing appropriate amounts of water with adequate electrolytes to avoid hypo-osmolar disturbances.
- Maximum daily amount of water that can be tolerated by population groups were not estimated. Estimates should be based on individual and environmental factors. However, very high intakes of water cannot be compensated by the excretion of very dilute urine (maximum urine volumes of about one litre / hour in adults). This can lead to hyponatraemic, hypo-osmolar water intoxication with cerebral oedema.

Table 5.1: Adequate Intakes (AIs)[1] for water (liters/day)

Age group	Male	Female
7 - 11 months	0.8 - 1.0	0.8 - 1.0
1 year	1.1-1.2	1.1-1.2
1 - 3 year	1.3	1.3
4 - 8 year	1.6	1.6
9 - 13 year	2.1	1.9
14 - 17 year	2.5	2.0
≥ 18 year	2.5	2.0
Pregnancy	-	2.3
Lactation	-	2.7

6) Vitamins

Vitamins are essential organic substances needed in small amounts in the diet to maintain fundamental functions of the body, such as growth, metabolism and cellular integrity. Vitamins facilitate energy-yielding chemical reactions rather than contribute energy. Thirteen vitamins plus the dietary component, choline, are considered dietary essentials for humans.

These include 8 B vitamins (thiamine, niacin, riboflavin, folate, vitamin B_6, vitamin B_{12}, biotin, and pantothenic acid); vitamin C (ascorbic acid); and the fat-soluble vitamins A, D, E, and K.

Vitamins are classified as water soluble and fat soluble according to their physical solubility in solvents. The fat-soluble vitamins (A, D, E, and K) dissolve in organic solvents and are less water soluble.

The B complex can be further divided according to general function:

- energy releasing (niacin, thiamine, riboflavin, biotin, and pantothenic acid) or
- haematopoietic (folate, B_6, and B_{12}).

Most vitamins are not related chemically and thus differ in their biochemical and physiological roles.

Sri Lankan DRI for vitamins are designed to reflect that latest understanding of vitamin requirements mainly based on recent EFSA recommendations.

Malabsorption, medications, certain diseases states, or excess of dietary substances such as alcohol can influence vitamin intake; the digestion, absorption, and transport of vitamins; and consequently, can alter vitamin requirements and status.

6.1) Biotin

Physiological role and functions

- Biotin serves as a co-factor for several carboxylases that play critical roles in the synthesis of fatty acids, the catabolism of branched-chain amino acids and gluconeogenesis.
- Free biotin is absorbed nearly completely. However, data is lacking on the absorption of protein-bound biotin from foods.
- In the cell, biotin is covalently attached to biotin-dependent carboxylases, from which it can be released by other enzymes, or, alternatively, is catabolised through different pathways.
- Biotin and its metabolites are excreted in the urine.
- Faecal excretion of biotin has been observed to be three to six times higher than intakes, owing to the production of large amounts of biotin by the intestinal microbiota; however, the extent to which biotin is absorbed from the large intestine and contributes to biotin requirements is uncertain.

Biotin deficiency

- Dietary biotin deficiency is rare.
- Cases of biotin deficiency have been observed in:
    - patients receiving long-term total parenteral nutrition without biotin supplementation
    - patients with biotinidase deficiency
    - people who had consumed large amounts of raw eggs (a protein in raw egg white, avidin, has a very high affinity for biotin and prevents its absorption in the small intestine).
- Symptoms include:
    - fine scaly dermatitis
    - hair loss
    - conjunctivitis
    - ataxia

Biotin excess

Not established (NE).

Requirements

Based on EFSA recommendations. AIs are based on observed biotin intakes with a mixed diet in the countries of European Union (EU) and the apparent absence of signs of deficiency and considering current intake levels are adequate.

Table 6.1.1: Biotin daily requirements (µg/day)

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	6	ND
Children	1-3 years	Both	NA	NA	20	ND
	4-6 years	Both	NA	NA	25	ND
	7-10 years	Both	NA	NA	25	ND
	11-17 years	Both	NA	NA	35	ND
Adults	≥ 18 years	Both	NA	NA	40	ND
Pregnant women	All trimesters	Female	NA	NA	40	ND
Lactating women	0-6 months postpartum	Female	NA	NA	45	ND

Table 6.1.2: Sources of biotin rich foods

Foods	Biotin content (µg)/100 g	Serving size	Biotin content /serving (µg)
Beef liver	36.2	30g	10.9
Egg	16.0	1 egg	10.0
Sweet potato, pink	4.8	½ cup	2.4
Pork chopped	4.5	30 g	1.2
Beet root	1.4	45g	0.7
Radish, round, white	2.5	45g	1.2
Cowpea	4.3	20g(raw), 3TBS (cooked)	0.86
Green gram, whole	1.3	20g(raw), 3TBS (cooked)	0.26
Lentil, dhal	1.1	20g(raw), 3TBS (cooked)	0.22
Bengal gram, whole	1.0	20g(raw), 3TBS (cooked)	0.2

6.2) Choline

Physiological role and functions

- The body needs choline to synthesize phosphatidylcholine and sphingomyelin, two major phospholipids vital for cell membranes. Therefore cells need choline to preserve their structural integrity.
- Choline is needed to produce acetylcholine, an important neurotransmitter for memory, mood, muscle control, and other brain and nervous system functions.
- Choline also plays important roles in modulating gene expression, cell membrane signaling, lipid transport and metabolism, and early brain development.
- Humans can produce choline endogenously in the liver, mostly as phosphatidylcholine, but the amount that the body naturally synthesizes is not sufficient to meet human needs. As a result, humans must obtain some choline from the diet.

Choline deficiency

Dietary deficiency of choline can cause:

- Fatty liver (hepatic steatosis) that can result in non-alcoholic fatty liver disease (NAFLD).
- Hepatic steatosis can progress to liver damage with release of liver enzymes into the blood.
- Muscle damage as indicated by an increase in creatine phosphokinase concentration in serum.
- Frank choline deficiency in healthy, nonpregnant individuals is very rare, possibly because of the contribution of choline that the body synthesizes endogenously.

Choline excess

- Hypotension
- Fishy body odor
- Vomiting,
- Excessive sweating and salivation,
- Liver toxicity

Requirements

Based on EFSA set AIs for choline considering data on observed choline intakes.

Table 6.2.1: Choline daily requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	160	ND
Children	1-3 years	Both	NA	NA	140	ND
	4-6 years	Both	NA	NA	170	ND
	7-10 years	Both	NA	NA	250	ND
	11-14 years	Both	NA	NA	340	ND
	15-17 years	Both	NA	NA	400	ND
Adults	≥ 18 years	Both	NA	NA	400	ND
Pregnant women	All trimesters	Female	NA	NA	480	ND
Lactating women	0-6 months postpartum	Female	NA	NA	520	ND

Table 6.2.2: Sources of choline rich foods

Foods	Choline content (mg) /100 g	Serving size	Choline content (mg) per serving
Beef liver	418.8	30g	125.6
Egg	183.8	1 large egg	147.0
Soya bean	214.0	½ cup	107.0
Milk, 1% fat	45.0	240ml	108.0
Chicken breast	84.7	85 g	72.0
Peanut, dry	48.0	½ cup	24.0

6.3) Folate (Vitamin B_9)

Physiological role and functions

- Folate functions as a coenzyme or co-substrate in single-carbon transfers in the synthesis of nucleic acids (DNA and RNA) and metabolism of amino acids.
- One of the most important folate-dependent reaction is the conversion of homocysteine to methionine in the synthesis of S-adenosyl-methionine, an important methyl donor for a wide range of substrates such as DNA, hormones, proteins, neurotransmitters and membrane phospholipids, all of which are regulators of important physiological processes.
- Another folate-dependent reaction, the methylation of deoxyuridylate to thymidylate in the formation of DNA, is required for proper cell division.

Folate deficiency

- Isolated folate deficiency is uncommon; folate deficiency usually coexists with other nutrient deficiencies because of its strong association with poor diet, alcoholism, and malabsorptive disorders.
- Megaloblastic anemia, which is characterized by large, abnormally nucleated erythrocytes, is the primary clinical sign of folate deficiency.
- Its symptoms include weakness, fatigue, difficulty in concentrating, irritability, headache, heart palpitations, and shortness of breath.
- Folate deficiency can also produce soreness in and shallow ulcerations on the tongue and oral mucosa; changes in skin, hair, or fingernail pigmentation; gastrointestinal symptoms; and elevated blood concentrations of homocysteine.
- Women with insufficient folate intakes are at increased risk of giving birth to infants with NTDs.
- Inadequate maternal folate status has also been associated with low infant birth weight, preterm delivery, and fetal growth retardation.

Folate excess

Neuropathy if B_{12} is deficient

Requirements

Based on EFSA recommendation considering the level need to maintain serum folate (≥10 nmol/L) and erythrocyte folate (≥340 nmol/L), both cut-off values are associated with lowest plasma homocysteine. It is related to food folate and folic acid. DFE is dietary folate equivalents. Natural food folates have a lower bioavailability than folic acid. DFE have been introduced to account for these differences. For combined intakes of food folate and folic acid, DFEs are computed as follows: μg DFE = μg food folate + (1.7 x μg folic acid). The UL applies to folic acid (synthetic) and given in μg/day.

Table 6.3.1: Folate requirements in DFE µg/day

	Age	Sex	AR	RDA	AI/RI	UL (µg/day)
Infants	7-11 months	Both	NA	NA	80	ND
Children	1-3 years	Both	90	120	NA	200
	4-6 years	Both	110	140	NA	300
	7-10 years	Both	160	200	NA	400
	11-14 years	Both	210	270	NA	600
	15-17 years	Both	250	330	NA	800
Adults	≥ 18 years	Both	250	330	NA	1000
Pregnant women	All trimesters	Female	NA	NA	600	1000
Lactating women	0-6 months postpartum	Female	380	500	NA	1000

Table 6.3.2: Sources of folate rich foods

Foods	Folate content (µg) /100 g	Serving size	Folate content /serving (µg)
Rice, white, medium grain	90	15g(raw), ½ cup(Cooked)	13.5
Cow pea, brown	273	20g(raw), ½ cup(cooked)	54.6
Bengal gram, whole	231	20g(raw), ½ cup(Cooked)	46.2
Cowpea, white	249	20g(raw), ½ cup(Cooked)	49.8
Gingelly seeds, black	119	15g	17.9

6.4) Vitamin A (retinols and carotenes)

Physiological role and functions

- Vitamin A is the name of a group of fat-soluble retinoids, including retinol, retinal, and retinyl esters.
- Two forms of vitamin A are available in the human diet: preformed vitamin A (retinol and its esterified form, retinyl ester) and provitamin A carotenoids.
- Vitamin A is an essential nutrient as humans do not have the capability for de novo synthesis of compounds with vitamin A activity.
- Vitamin A is involved in immune function, vision, reproduction, and cellular communication.
- Vitamin A is critical for vision as an essential component of rhodopsin, a protein that absorbs light in the retinal receptors, and because it supports the normal differentiation and functioning of the conjunctival membranes and cornea.
- Vitamin A also supports cell growth and differentiation, playing a critical role in the normal formation and maintenance of the heart, lungs, kidneys, and other organs.

Vitamin A deficiency

- Symptoms of vitamin A deficiency involve several functions, such as:
  - vision (xerophthalmia)
  - immunity
  - reproduction
- Worsening of low iron status
- Follicular hyperkeratosis

Vitamin A excess

- Chronic intakes of excess vitamin A lead to increased intracranial pressure (pseudotumor cerebri), dizziness, nausea, headaches, skin irritation, pain in joints and bones, coma, and even death.
- Teratogenicity.

Requirements

Based on EFSA recommendation considering the average intake needed to establish adequate liver stores of 20 µg/g liver tissue. It is related to vitamin A in the form of retinol, retinyl esters and provitamin A carotenoids as retinol equivalent (RE). Provitamin A carotenoids have a lower bioavailability than retinol. Considering these differences, RE have been introduced and defined as 1 µg RE = 1 µg of retinol = 6 µg of β-carotene = 12 µg of other carotenoids with provitamin A activity. The UL applies to vitamin A as retinol or retinyl esters. There were no adequate data to derive a UL for β-carotene.

Table 6.4.1: Vitamin A requirements in µg Retinol Equivalent (RE)/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	190	250	NA	ND
Children	1-3 years	Both	205	250	NA	800
	4-6 years	Both	245	300	NA	1100
	7-10 years	Both	320	400	NA	1500
	11-14 years	Both	480	600	NA	2000
	15-17 years	Male	580	750	NA	2600
		Female	490	650	NA	2600
Adults	≥ 18 years	Male	570	750	NA	3000
		Female[1]	490	650	NA	3000
Lactating women	0-6 months postpartum	Female	1020	1300	NA	3000

([1]EFSA values for post-menopausal adult female was not taken)

Table 6.4.2: Sources of vitamin A rich foods

Foods	Vitamin A content (µg RE)/100 g	Serving size	Vitamin A content/ serving (µg RE)
Beef liver	7959	30g	2387
Chicken broiler liver	3486	30g	1045
Amaranth leaves green	1474	50g	737
Amaranth leaves red	1409	50g	708
Drumstick leaves	2664	20g	532
Hummingbird leaves (kathurumurunga)	2097	25g	524
Carrot	1240	50g	620

6.5) Vitamin B_1 (Thiamine)

Physiological role and functions
• Free thiamine functions as the precursor for Thiamine diphosphate (TDP), which acts as a coenzyme for enzymes involved in carbohydrate and branched-chain amino acid metabolism, and in energy-yielding reactions. • Thiamine plays a critical role in energy metabolism and, therefore, in the growth, development, and function of cells.

Thiamine deficiency
• In its early stage, thiamin deficiency can cause weight loss and anorexia, confusion, short-term memory loss, and other mental signs and symptoms; muscle weakness; and cardiovascular symptoms (such as an enlarged heart) • Beriberi, with mostly neurological and cardiovascular manifestations • Wernicke's encephalopathy (ocular abnormalities, ataxia, disturbances of consciousness) • Korsakoff's syndrome (psychosis) resulting in amnesia, disorientation and often confabulation.

Thiamine excess
• The body excretes excess amounts of thiamin in the urine. • However, the US/FNB noted that in spite of the lack of reported adverse events, excessive intakes of thiamin could have adverse effects.

Requirements
Based on EFSA recommendation considering erythrocyte transketolase activity. Thiamine requirement is related to energy requirement, and it was calculated based on the energy requirement of the group considered.

Table 6.5.1: Thiamine requirements in mg/kcal/day

	Age	Sex	PAL	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	-	0.0003	0.0004	NA	ND
Children	1-3 years	Both	-	0.0003	0.0004	NA	ND
	4-6 years	Both	1.4	0.0003	0.0004	NA	ND
			1.7	0.0003	0.0004	NA	ND
	7-10 years	Both	1.4	0.0003	0.0004	NA	ND
			1.7	0.0003	0.0004	NA	ND
	11-14 years	Male	1.7	0.0003	0.0004	NA	ND
			2.0	0.0003	0.0004	NA	ND
		Female	1.7	0.0003	0.0004	NA	ND
			2.0	0.0003	0.0004	NA	ND
	15-17 years	Male	1.7	0.0003	0.0004	NA	ND
			2.0	0.0003	0.0004	NA	ND
		Female	1.7	0.0003	0.0004	NA	ND
			2.0	0.0003	0.0004	NA	ND
Adults	≥18 years	Male	1.4	0.0003	0.0004	NA	ND
			1.7	0.0003	0.0004	NA	ND
			2.0	0.0003	0.0004	NA	ND
		Female	1.4	0.0003	0.0004	NA	ND
			1.7	0.0003	0.0004	NA	ND
			2.0	0.0003	0.0004	NA	ND
Pregnant	1st trimesters	Female	-	0.0003	0.0004	NA	ND
	2ndtrimesters		-	0.0003	0.0004	NA	ND
	3rd trimesters		-	0.0003	0.0004	NA	ND
Lactating	0-6 m pp	Female	-	0.0003	0.0004	NA	ND

Table 6.5.2: Sources of thiamin (B_1) rich foods

Food	Thiamin content (mg) /100g	Serving size	Thiamine content (mg) /serving
Brown cowpea	0.5	20g(raw), 3TBS (cooked)	0.5
Whole green gram	0.42	20g(raw), 3TBS (cooked)	0.4
Wheat semolina	0.26	3 TBS	0.1
Whole egg	0.14	1 egg	0.1
Broiler chicken liver	0.28	30g	0.08
Rice, parboiled	0.14	15g(raw), ½ cup (cooked)	0.06

6.6) Vitamin B_2 (Riboflavin)

Physiological role and functions

- Riboflavin is an integral part of the coenzymes Flavin Adenine Dinucleotide (FAD) and Flavin Mono Nucleotide (FMN) that act as the cofactors of flavoprotein enzymes involved in a variety of reactions.
- FAD and FMN act as proton carriers in redox reactions involved in energy metabolism, metabolic pathways and the formation of some vitamins and coenzymes.
- Riboflavin is involved in the metabolism of niacin and vitamin B_6.
- Bacteria in the large intestine produce free riboflavin that can be absorbed by the large intestine in amounts that depend on the diet.
- More riboflavin is produced after ingestion of vegetable-based than meat-based foods

Riboflavin deficiency

Inadequate intake include

- endocrine abnormalities (such as thyroid hormone insufficiency) and some diseases.

Signs and symptoms of riboflavin deficiency (also known as ariboflavinosis) include

- skin disorders, hyperemia (excess blood) and edema of the mouth and throat, angular stomatitis (lesions at the corners of the mouth), cheilosis (swollen, cracked lips), hair loss, reproductive problems, sore throat, itchy and red eyes, and degeneration of the liver and nervous system.
- People with riboflavin deficiency typically have deficiencies of other nutrients, so some of these signs and symptoms might reflect these other deficiencies.
- Severe riboflavin deficiency can impair the metabolism of other nutrients, especially other B vitamins, through diminished levels of flavin coenzymes.
- Anaemia and cataracts can develop if riboflavin deficiency is severe and prolonged.

Riboflavin excess

- Not established.
- However, that high intakes have no adverse effects, and the US/FNB urges people to be cautious about consuming excessive amounts of riboflavin.

Requirements

Based on EFSA recommendation considering urinary riboflavin excretion. The intake at which urinary riboflavin sharply increases in line with Erythrocyte Glutathione Reductase Activation Coefficient <1.3. It is related to riboflavin in the form of free riboflavin, flavin mononucleotide and flavin adenine dinucleotide.

Table 6.6.1: Riboflavin requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	0.4	ND
Children	1-3 years	Both	0.5	0.6	NA	ND
	4-6 years	Both	0.6	0.7	NA	ND
	7-10 years	Both	0.8	1	NA	ND
	11-14 years	Both	1.1	1.4	NA	ND
	15-17 years	Both	1.4	1.6	NA	ND
Adults	≥ 18 years	Both	1.3	1.6	NA	ND
Pregnant women	All trimesters	Female	1.5	1.9	NA	ND
Lactating women	0-6 months postpartum	Female	1.7	2.0	NA	ND

Table 6.6.2: Sources of Riboflavin rich foods

Food	Riboflavin content (mg) /100g	Serving size	Riboflavin content (mg)/serving
Milk- cow, liquid, non-fat	0.28	240ml	0.67
Milk - cow, powdered, skimmed	1.64	30g	0.49
Baby shrimps	2.18	15g	0.32
Cheese cheddar, regular fat	0.64	1 slice	0.19
Yoghurt, whole	0.23	80g	0.18
Egg, whole	0.19	1 egg	0.14
Beef liver	0.31	30g	0.09

6.7) Vitamin B_3 (Niacin)

Physiological role and functions
• Niacin is the generic name for nicotinic acid (pyridine-3-carboxylic acid), nicotinamide (niacinamide or pyridine-3-carboxamide), and related derivatives, such as nicotinamide riboside. • Niacin function as the precursor of the nicotinamide nucleotide coenzymes NAD and the coenzyme nicotinamide adenine dinucleotide phosphate (NADP), which are involved in oxidation/reduction reactions an associated with both catabolic and anabolic processes. • NAD is also required for enzymes involved in critical cellular functions, such as the maintenance of genome integrity, control of gene expression, and cellular communication. NADP, in contrast, enables anabolic reactions, such as the synthesis of cholesterol and fatty acids, and plays a critical role in maintaining cellular antioxidant function. • Niacin can be synthesised in the human body from the indispensable amino acid tryptophan.

Niacin deficiency
• Pellagra, symptoms include: o Photosensitive dermatitis (pigmented rash that develops symmetrically in areas exposed to sunlight) o Skin lesions o Tongue and mouth soreness o Vomiting o Diarrhoea o Depression o Dementia o If untreated: death from multiorgan failure o Early symptoms are usually non-specific and include weakness, loss of appetite, fatigue, digestive disturbances, abdominal pain irritability

Niacin excess
• Flushing; The flushing is accompanied by burning, tingling, and itching sensations; the flushing can be accompanied by more serious signs and symptoms, such as headache, rash, dizziness, and/or a decrease in blood pressure

Requirements

Based on EFSA recommendation considering excretion of niacin metabolites, considering preformed niacin or tryptophan required to restore normal urinary excretion of N-methyl nicotinamide and 2-Pyridone-5-carboxamide. It is related to niacin in the form of nicotinamide and nicotinic acid. NE: niacin equivalent (1 NE = 1 mg niacin = 60 mg dietary tryptophan). Niacin requirement is related to energy requirement, and it is calculated based on the energy requirement of the group considered.

Table 6.7.1: Niacin requirements in NE/kcal/day

	Age	Sex	PAL	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	-	0.0055	0.0066	NA	ND
Children	1-3 years	Both	-	0.0055	0.0066	NA	150 mg Nicotinamide 2mg Nicotinic acid
	4-6 years	Both	1.4	0.0055	0.0066	NA	220 mg Nicotinamide 3 mg Nicotinic acid
			1.7	0.0055	0.0066	NA	
	7-10 years	Both	1.4	0.0055	0.0066	NA	350 mg Nicotinamide 4 mg Nicotinic acid
			1.7	0.0055	0.0066	NA	
	11-14 years	Male	1.7	0.0055	0.0066	NA	500 mg Nicotinamide 6 mg Nicotinic acid
			2.0	0.0055	0.0066	NA	
		Female	1.7	0.0055	0.0066	NA	
			2.0	0.0055	0.0066	NA	
	15-17 years	Male	1.7	0.0055	0.0066	NA	700 mg Nicotinamide 8 mg Nicotinic acid
			2.0	0.0055	0.0066	NA	
		Female	1.7	0.0055	0.0066	NA	
			2.0	0.0055	0.0066	NA	
Adults	≥18 years	Male	1.4	0.0055	0.0066	NA	900 mg Nicotinamide 10 mg Nicotinic acid
			1.7	0.0055	0.0066	NA	
			2.0	0.0055	0.0066	NA	
		Female	1.4	0.0055	0.0066	NA	
			1.7	0.0055	0.0066	NA	
			2.0	0.0055	0.0066	NA	
Pregnant	1st trimester	Female	-	0.0055	0.0066	NA	ND
	2nd trimester		-	0.0055	0.0066	NA	ND
	3rd trimester		-	0.0055	0.0066	NA	ND
Lactating	0-6 m pp	Female	-	0.0055	0.0066	NA	ND

Table 6.7.2: Sources of niacin rich foods

Food	Niacin content (mg) /100g	Serving size	Niacin content (mg) /serving
Beef liver	13.8	30g	4.14
Chicken, broiler	8.4	30 g	2.8
Ground nut	11.6	15g	1.74
Skim milk powdered	4.7	30g	1.4
Tuna	4.5	30 g	1.35
Bengal gram, whole	1.5	20g(raw),3TBS (cooked)	0.3
Rice, samba	1.2	15g(raw), ½ cup (cooked)	0.18

6.8) Vitamin B_5 (Pantothenic acid)

Physiological role and functions
• Pantothenic acid is a component of coenzyme A and acyl-carrier proteins and serves in acyl-group activation and transfer, which is essential for fatty acid synthesis and oxidative degradation of fatty acids and amino acids. • Humans cannot synthesise pantothenic acid and depend on its dietary intake. • Pantothenic acid ubiquitous in food.

Pantothenic acid deficiency
• Symptoms include: o Mood changes o Sleep disturbances o Neurological disturbances o Cardiac disturbances • Gastrointestinal disturbances • a deficiency is associated with numbness and burning of the hands and feet, headache, fatigue, irritability, restlessness, disturbed sleep, and gastrointestinal disturbances with anorexia.

Pantothenic acid excess
Not established.

Requirements
EFSA recommendation - Based on approximate midpoint of the observed median/mean intakes; there are no signs of insufficiencies.

Table 6.8.1: Pantothenic acid requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	3	ND
Children	1-3 years	Both	NA	NA	4	ND
	4-10 years	Both	NA	NA	4	ND
	11-17 years	Both	NA	NA	5	ND
Adults	≥ 18 years	Both	NA	NA	5	ND
Pregnant women	All trimesters	Female	NA	NA	5	ND
Lactating women	0-6 months postpartum	Female	NA	NA	7	ND

Table 6.8.2: Sources of Pantothenic acid rich foods

Food	Pantothenic acid content (mg) /100g	Serving size	Pantothenic acid Content(mg)/serving
Beef liver	8.3	30g	2.49
Milk,cow 2% fat	0.4	240ml	0.96
Egg, boiled	0.7	1 large	0.6
Ground nut	1.0	15g	0.15
Rice, brown	0.4	15g(raw), ½ cup (cooked)	0.06

6.9) Vitamin B_6

Physiological role and functions

- Plasma pyridoxal 5-phosphate is the predominant active form of vitamin B_6 that functions as a coenzyme in various metabolic reactions such as amino acid metabolism, glycogenolysis, gluconeogenesis, haem synthesis, niacin formation, lipid metabolism, neurotransmitter synthesis and hormone action.

Vitamin B_6 deficiency

- Rare. Symptoms include:
  - Hypochromic microcytic anaemia
  - Neurological abnormalities (hyperirritability, convulsive seizures and abnormal electroencephalograms)
  - Eczema
  - Seborrheic dermatitis
  - Cheilosis
  - Glossitis
  - Angular stomatitis

Vitamin B_6 excess

Neurotoxicity

Requirements

Based on plasma pyridoxal 5-phosphate >30nmol/L. AR for women, and then extrapolated to men via allometric scaling. It is related to vitamin B_6 in the form of pyridoxine, pyridoxal, pyridoxamine and their phosphorylated forms.

Table 6.9.1: Vitamin B_6 requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	0.3	ND
Children	1-3 years	Both	0.5	0.6	NA	5
	4-6 years	Both	0.6	0.7	NA	7
	7-10 years	Both	0.9	1	NA	10
	11-14 years	Both	1.2	1.4	NA	15
	15-17 years	Male	1.5	1.7	NA	20
		Female	1.3	1.6	NA	20
Adults	≥ 18 years	Male	1.5	1.7	NA	25
		Female	1.3	1.6	NA	25
Pregnant women	All trimesters	Female	1.5	1.8	NA	25
Lactating women	0-6 months postpartum	Female	1.4	1.7	NA	25

Table 6.9.2: Sources of Vitamin B_6 rich foods

Food	Vitamin B_6 content (mg) /100g	Serving size	Vitamin B_6 content (mg)/serving
Baby shrimps	3.44	15g	0.51
Banana, ripe, ambul	0.64	80g	0.51
Sardinella, spotted	1.66	30g	0.50
Skipjack tuna	1.64	30g	0.49
Maldives fish	2.99	15g	0.44
Banana, ripe, pome	0.51	80g	0.40
Chicken liver	0.92	30g	0.28
Pomegranate, maroon seeds	0.30	80g	0.24
Chicken breast, skinless	0.49	30g	0.15
Pistachio nut	0.96	15g	0.14
Gingelly seeds, black	0.69	15g	0.10

6.10) Vitamin B_{12} (Cobalamin)

Physiological role and functions

- Vitamin B_{12} contains the mineral cobalt, compounds with vitamin B_{12} activity are collectively called "cobalamins"
- Vitamin B_{12} is required for the development, myelination, and function of the central nervous system; healthy red blood cell formation; and DNA synthesis
- Vitamin B_{12} functions as a cofactor for two enzymes, methionine synthase and L-methylmalonyl-CoA mutase. Methionine synthase catalyzes the conversion of homocysteine to the essential amino acid methionine. Methionine is required for the formation of S-adenosylmethionine, a universal methyl donor for almost 100 different substrates, including DNA, RNA, proteins, and lipids. L-methylmalonyl-CoA mutase converts L-methylmalonyl-CoA to succinyl-CoA in the metabolism of propionate, a short-chain fatty acid.
- Vitamin B_{12} is bound to protein in food and must be released before it is absorbed. The process starts in the mouth when food is mixed with saliva. The freed vitamin B_{12} then binds with haptocorrin, a cobalamin-binding protein in the saliva.
- More vitamin B_{12} is released from its food matrix by the activity of hydrochloric acid and gastric protease in the stomach, where it then binds to haptocorrin.
- In the duodenum, digestive enzymes free the vitamin B_{12} from haptocorrin, and this freed vitamin B_{12} combines with intrinsic factor, a transport and delivery binding protein secreted by the stomach's parietal cells.

Vitamin B_{12} deficiency

Symptoms include:

- megaloblastic anaemia
  - glossitis of the tongue; fatigue; palpitations; pale skin; dementia; weight loss; and infertility
- neurological dysfunction due to progressive demyelinating lesions of white matter in spinal cord and brain. These neurological symptoms can occur without anemia early diagnosis and intervention is important to avoid irreversible damage.
  - numbness and tingling in the hands and feet
  - myelopathy
  - neuropathy
  - neuropsychiatric abnormalities
  - optic nerve atrophy (less often)
  - clinical cerebral features associated with mental symptoms
  - irritability
  - memory disturbances
  - depression
  - In severe deficiency or advanced stages

  - dementia like illness
  - frank psychosis with hallucination
  - paranoia
- Cobalamin insufficiency is characterised by biochemical abnormalities
  - elevated total homocysteine (tHcy) and/or methylmalonic acid (MMA) concentrations in blood resulting from impaired cobalamin metabolic activity, with no specific clinical symptoms.
- In pregnant and breastfeeding women, vitamin B_{12} deficiency might cause neural tube defects, developmental delays, failure to thrive, and anaemia in offspring

Vitamin B_{12} excess

Not established. Even at large doses, vitamin B12 is generally considered to be safe because the body does not store excess amounts.

Requirements

Based on EFSA recommendation considering AI to maintain haemotological status and normal serum B_{12}.

Table 6.10.1: Vitamin B_{12} daily requirements in µg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	1.5	ND
Children	1-3 years	Both	NA	NA	1.5	ND
	4-6 years	Both	NA	NA	1.5	ND
	7-10 years	Both	NA	NA	2.5	ND
	11-14 years	Both	NA	NA	3.5	ND
	15-17 years	Both	NA	NA	4	ND
Adults	≥ 18 years	Both	NA	NA	4	ND
Pregnant women	All trimesters	Female	NA	NA	4.5	ND
Lactating women	0-6 months postpartum	Female	NA	NA	5	ND

Table 6.10.2: Sources of vitamin B12 rich foods

Foods	B12 content (µg) /100 g	Serving size	B12 content (µg)/serving
Beef liver	83.2	30g	25
Fish, Tuna	10.9	30g	3.3
Milk, liquid 2% fat	0.7	240ml	1.68
Yeast extract	15.0	1 teaspoon	0.6
Egg, boiled	0.6	1 egg	0.5

6.11) Vitamin C (ascorbic acid)

Physiological role and functions

- Vitamin C has several biochemical and physiological functions in the body, which are largely dependent on its ability to provide reducing equivalents in various biochemical reactions.
- Vitamin C is an enzyme cofactor for biochemical reactions catalysed by monooxygenase, dioxygenase and mixed function oxygenase.
- Vitamin C plays an important role in the biosynthesis of collagen and the synthesis of carnitine.
- Vitamin C is a cofactor in the conversion of dopamine to noradrenaline, is involved in the metabolism of cholesterol to bile acids and has various effects in the body.

Vitamin C deficiency

- Symptoms include:
    - Scurvy, characterised by symptoms related to connective tissue defects that results from a weakening of collagenous structures
        - Tooth loss
        - Joint pain
        - Bone and connective tissue disorders
        - Poor wound healing
        - Depression
        - Hypochondria
        - Mood changes may be related to deficient dopamine hydroxylation
- Early or prescorbutic symptoms
    - Fatigue
    - lethargy
    - Anaemia
    - Aching joints
    - Muscle weakness

Vitamin C excess

Gastrointestinal effects

Requirements

Based on adequate body pool. Daily intake value associated with a plasma concentration of vitamin C of 50 µmol/L and adjusted the value up to compensate for urinary losses.

Table 6.11.1: Vitamin C requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	20	NA	ND
Children	1-3 years	Both	15	20	NA	ND
	4-6 years	Both	25	30	NA	ND
	7-10 years	Both	40	45	NA	ND
	11-14 years	Both	60	70	NA	ND
	15-17 years	Male	85	100	NA	
		Female	75	90	NA	ND
Adults	≥ 18 years	Male	90	110	NA	ND
		Female	80	95	NA	ND
Pregnant women*	All trimesters	Female	90	105	NA	ND
Lactating women	0-6 months postpartum	Female	140	155	NA	ND

*ICMR AR was adopted due to non-available AR from EFSA

Table 6.11.2: Sources of Vitamin C rich foods

Food	Vitamin Content (mg) /100g	Serving size	Vitamin C content (mg) /serving
Guava-pink flesh	244mg	50g	122mg
Guava – white flesh	212mg	50g	106mg
Amaranth- red	86mg	100g	86mg
Mango green	91.63mg	50g	45.81mg
Amaranth- green	82mg	50g	41mg

6.12) Vitamin D (ergocalciferol and cholecalciferol)

Physiological role and functions

- In the body vitamin D is converted to the main circulating form, calcitriol (25(OH)D), which can be transformed into the biologically active calcitriol (1.25(OH)2D).
- The principal function of the calcitriols is to maintain calcium and phosphorous homeostasis in the circulation, together with parathyroid hormone and fibroblast growth factor.
- The main target tissues of calcitriol are the intestine, the kidneys and bone.
- Vitamin D is in the form of ergocalciferol (vitamin D_2) and cholecalciferol (vitamin D_3).

Vitamin D deficiency

- Symptoms include:
    - o Osteomalacia, caused by the impaired mineralisation of bone due to an inefficient absorption of dietary calcium and phosphorus.
    - o Clinical symptoms may include:
        - diffuse pain in muscles and bone,
        - muscle pain and weakness,
        - poor physical performance,
        - increased of falls/falling, and
        - a higher risk of bone fractures
- Prolonged vitamin D insufficiency may lead to
    - low bone mineral density,
    - osteoporosis, a situation characterised by a
        - o reduction in bone mineral,
        - o reduced bone quality and
        - o an increased risk of bone fracture, predominantly in the forearm, vertebrae and hip.

Vitamin D excess

High serum calcium

Requirements

Based on EFSA recommendation considering the need to achieve serum 25-hydroxyvitamin D at 40 nmol/L. The setting of the AI for vitamin D, it was assumed minimal cutaneous vitamin D synthesis. In the presence of endogenous vitamin D synthesis, the requirement for dietary vitamin D is lower or may even be zero.

Table 6.12.1: Vitamin D requirements in µg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	10	35
Children	1-3 years	Both	NA	NA	15	50
	4-6 years	Both	NA	NA	15	50
	7-10 years	Both	NA	NA	15	50
	11-14 years	Both	NA	NA	15	100
	15-17 years	Both	NA	NA	15	100
Adults	≥ 18 years	Both	NA	NA	15	100
Pregnant women	All trimesters	Female	NA	NA	15	100
Lactating women	0-6 months postpartum	Female	NA	NA	15	100

Table 6.12.2: Sources of Vitamin D rich foods

Food	Vitamin D content (µg) /100g	Serving size	Vitamin D content (µg)/serving
Gingerly seeds(brown)	73	15g	11
Gingerly seeds(black)	65.6	15g	10
Amaranth	15	50g	7.5
Egg whole (Country)	4.46	1 egg	4
Lentil, whole, yellow	18	20 g	3.6
Fortified Margarine (Astra/Meadow lea)	20-10	15g	3-1.5
Eel	6.66	30g	2
Wheat flour atta	13	15 g	1.95
Pork (Shoulder)	5.63	30g	1.7
Prawn(giant)	4.77	30g	1.4
Cat fish (Anguluwa)	3.77	30g	1.1
Sardinella white (Sudaya)	3.51	30g	1.05
Anchovy (Hadalla)	3.31	30g	1
Travelly blacktip(Guru parawa)	3.3	30g	0.99
Tuna mackerel (Ata walla)	3.26	30g	0.98
Egg- whole (Farm)	0.92	1 egg	0.9
Chicken liver	2.62	30g	0.8
Cashew nut	3.78	15g	0.6

6.13) Vitamin E (alpha-tocopherol)

Physiological role and functions
α-Tocopherol is a peroxyl radical scavenger and especially protects PUFAs within membrane phospholipids and plasma lipoproteins. By protecting PUFAs within membrane phospholipids, α-tocopherol preserves intracellular and cellular membrane integrity and stability, and plays an important role in the stability of erythrocytes and in the conductivity in central and peripheral nerves. Symptomatic α-tocopherol deficiency in individuals without any disease and who consume diets 'low' in α-tocopherol has not been reported. Primary vitamin E deficiency, i.e. familial isolated α-tocopherol deficiency, results from a genetic defect in the α-TTP gene. Secondary vitamin E deficiency has been observed in specific patient groups (abetalipoproteinaemia, cholestatic liver diseases, severe malnutrition, fat malabsorption, and cystic fibrosis).

Vitamin E deficiency

- Vitamin E deficiency is stated to be very rare and usually not caused by inadequate intakes.
- Symptoms include:
  - haemolytic anaemia
  - neurological symptoms
    - ataxia,
    - peripheral neuropathy,
    - myopathy,
    - pigmented retinopathy

Vitamin E excess
Blood clotting

Requirements
Based on EFSA recommendation the amount to prevent peroxide-induced haemolysis. EARs apply only to the 2R-stereoisomeric forms of α-tocopherol found in foods, fortified foods, and supplements. Other forms of vitamin E, such as γ-tocopherol (the predominant form in maize, for example) were deemed not to be useful for meeting vitamin E requirements.

Table 6.13.1: Vitamin E as α-tocopherol requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	5	ND
Children	1-3 years[1]	Both	NA	NA	6	100
	4-6 years	Both	NA	NA	9	120
	7-10 years[2]	Both	NA	NA	9	160
	11-14 years	Male	NA	NA	13	220
		Female	NA	NA	11	220
	15-17 years	Male	NA	NA	13	260
		Female	NA	NA	11	260
Adults	≥ 18 years	Male	NA	NA	13	300
		Female	NA	NA	11	300
Pregnant women	All trimesters	Female	NA	NA	11	300
Lactating women	0-6 months postpartum	Female	NA	NA	11	300

([1,2]EFSA recommended 1-2 years for 1-3 years and 7-9 years for 7-10 years were taken)

Table 6.13.2: Sources of Vitamin E rich foods

Food	Vitamin E content (mg) /100g	Serving size	Vitamin E content (mg)/serving
Safflower seeds	35	1 TBS (15g)	5.25
Almonds	25.1	1 TBS (15g)	3.76
Pistachio seeds	24.48	1 TBS (15g)	3.67
Sunflower seeds	12	1 TBS (15g)	1.8
Coconut kernel, dry	5.28	1 TBS (10g)	0.79

6.14) Vitamin K (phylloquinone)

Physiological role and functions

- Different vitamin K-dependent Gla-proteins display calcium-mediated actions.
- One group of vitamin K-dependent proteins comprises blood coagulation factors.
- Another group includes a protein involved in bone mineralisation and other proteins which may be involved in the control of soft tissue calcification.
- Vitamin K naturally occurs in food as phylloquinone (vitamin K1) and menaquinones (vitamin K2).

Vitamin K deficiency

- In adults, vitamin K deficiency is clinically characterised by:
    - o a bleeding tendency in relation to a low activity of the blood coagulation factors.

Vitamin K excess

Not established

Requirements

Based on EFSA recommendation considering an adequate intake of 1 µg/kg per day

Table 6.14.1: Vitamin K as phylloquinone requirements in µg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	10	ND
Children	1-3 years	Both	NA	NA	12	ND
	4-6 years	Both	NA	NA	20	ND
	7-10 years	Both	NA	NA	30	ND
	11-14 years	Both	NA	NA	45	ND
	15-17 years	Both	NA	NA	65	ND
Adults	≥ 18 years	Both	NA	NA	70	ND
Pregnant women	All trimesters	Female	NA	NA	70	ND
Lactating women	0-6 months postpartum	Female	NA	NA	70	ND

Table 6.14.2: Sources of Vitamin K rich foods

Food	Vitamin K content (mg) /100g	Serving size	Vitamin K content (mg)/serving
Amaranth	441mg	50g	220mg
Malabar spinach	351mg	50g	175mg
Papaya raw	312mg	50g	156mg
Drumstick leaves	350mg	25g	87mg
Colocasia leaves	390mg	25g	97mg

7) Minerals & Trace Elements

Minerals and trace elements are required for virtually all aspects of metabolism. Deficiencies of minerals and trace elements generally occur in several phases, with alterations in metabolism occurring at a biochemical, clinical, morphological, and /or functional level. Generally, the biochemical alterations occur before evidence of any other changes. Subtle physiological changes sometimes associated with trace element deficiency often make a diagnosis difficult. In addition, trace elements interact with each other and may influence or interfere with the absorption of select minerals.

The body needs many minerals; these are called essential minerals. Essential minerals are sometimes divided up into major minerals (macrominerals) and trace elements/minerals (microminerals). These two groups of minerals are equally important, but trace minerals are needed in smaller amounts than major minerals. The amounts needed in the body are not an indication of their importance.

There are 7 major minerals, namely sodium, chloride, potassium, calcium, phosphorus, magnesium and sulphur.

There are 14 trace elements, namely iron, copper, zinc, boron, selenium, nickel, molybdenum, manganese, lead, arsenic, chromium, cobalt, vanadium, and cadmium. Iron is considered as a trace mineral, although the amount needed is somewhat more than for other microminerals. Boron, nickel, cobalt and vanadium are essential in tiny amounts.

Considering the availability of data, daily requirements are considered for 6 major minerals and 9 trace elements. Most of the requirements are based on recent EFSA recommendations. Otherwise, IOM and ICMR/NIN recommendations were adopted.

7.1) Calcium

Physiological role and functions

- Calcium is an integral component of the skeleton; approximately 99% of total body calcium is found in bones and teeth, where it is mainly present as calcium hydroxyapatite.
- It has a structural role, and is needed for tissue rigidity, strength, and elasticity.
- The remaining 1% of calcium found in the body acts as an essential intracellular messenger in cells and tissues.
- It has a critical role in many physiological functions involved in the regulation of metabolic processes, including vascular contraction and vasodilation, muscle contraction, enzyme activation, neural transmission, membrane transport, glandular secretion, and hormone function.

Calcium deficiency

- A low intake of calcium often co-exists with vitamin D deficiency.
- Older adults with osteomalacia will have a reduced bone mass which leads to impaired bone strength.
- Genetic and environmental factors play a role in the prevention of osteopenia, osteoporosis and bone fracture
- If the dietary supply of calcium is insufficient to meet physiological requirements, calcium is resorbed from the skeleton to maintain blood concentrations within the range required for normal cellular and tissue functions. This causes a reduction in bone mass, which leads to osteopenia and osteoporosis, and an associated increased risk of fracture.

Calcium excess

Milk alkali syndrome

Requirements

Based on balance data and calcium supplementations as recommended by EFSA. Following factors were also considered in recommending calcium AI.

- AI of infants aged 7–11 months - exclusively breast-fed infants (120 mg/day), extrapolating upwards using isometric scaling and an absorption of 60% was assumed.
- AI of children aged 1–17 years - a factorial approach was employed where the quantity of dietary calcium that is sufficient for calcium accretion in bone and for replacement of obligatory body losses in 50% of the population.

- AI of young adults (18–24 years) – consider they still accumulate calcium in bones, the intermediate value between children aged 11–17 years and adults were taken.
- AI of pregnancy and lactation - adaptive changes in calcium metabolism during the period was considered.

Table 7.1.1: Calcium requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	280	NE
Children	1-3 years	Both	390	450	-	NE
	4-10 years	Both	680	800	-	NE
	11-17 years	Both	960	1150	-	NE
Adults	18-24 years	Both	860	1000	-	2500
	≥ 25 years	Both	750	950	-	2500
Pregnant women*	All trimesters	Female	750	950	-	2500
Lactating women	0-6 months postpartum	Female	750	950	-	2500

*Considering majority of pregnant women in Sri Lanka is above > 25 years, EFSA recommended daily requirements for ≥ 25 years was adopted.

Table 7.1.2: Sources of Calcium rich foods

Food	Ca content(mg) /100g	Serving size	Ca content (mg)/serving
Cow s milk powdered-skim	1370	30g	410
Goat milk-whole	152	240ml	350
Cow s milk liquid-low fat	127	240ml	300
Baby Shrimps	1978	15g	296
Cow s powdered -FCM	959	30g	288
Cow s milk liquid-FCM	103	240ml	247
Gingelly seeds (black)	1465	15g	219
Cottage cheese paneer	790	25g	197
Amaranth leaves	359	50g	179
Sprats	1178	15g (~9 sprats)	176
Yoghurt whole	127	100g	127
Curd-buffalo, whole	90	100g	90

7.2) Chloride

Physiological role and functions
• Chloride is the predominant anion in intracellular fluid and one of the most important extracellular anions. • It contributes to many body functions including the maintenance of osmotic and acid–base balance, muscular and nervous activity, and the movement of water and solutes between fluid compartments. • Main dietary source of chloride intake is sodium chloride.

Chloride deficiency
• Failure to thrive in infants, constipation, food refusal, muscular weakness, delayed psychomotor development, dehydration

Chloride excess
Not established

Requirements
Based on EFSA recommendation, considering assumptions of reference values for chloride is equimolar to the reference values for sodium for all population groups.

Table 7.2.1: Chloride requirements in g/day

	Age	Sex	AR	RDA	AI/RI/ safe and adequate intake	UL
Infants	7-11 months	Both	NA	NA	0.3	NA
Children	1-3 years	Both	NA	NA	1.7	NA
	4-10 years	Both	NA	NA	2	NA
	11-17 years	Both	NA	NA	2.6	NA
Adults	≥ 18 years	Both	NA	NA	3.1	NA
Pregnant women	All trimesters	Female	NA	NA	3.1	NA
Lactating women	0-6 months postpartum	Female	NA	NA	3.1	NA

Table 7.2.2: Sources of Chloride rich foods

Food	Chloride content (mg) /100g	Serving size	Chloride content (mg) /serving
Potato	926	1 medium (100 g)	926
Swiss chard	1922	1 cup (50 g)	961
Squash/ acorn	640	1 cup (140 g)	896
Orange juice	177	1 cup (240 ml)	426
Banana	468	1 medium (90 g)	422
Cantaloupe	304	1 cup (140 g)	426

7.3) Chromium

Physiological role and functions
• Trivalent chromium has been postulated to be necessary for the efficacy of insulin in regulating metabolism of carbohydrates, lipids and protein.

Chromium deficiency
• Chromium deficiency has not been reported in healthy populations. Patients with long term parenteral nutrition experienced adverse metabolic and neurological e ects, including hyperglycaemia, glycosuria, unexplained weight loss, peripheral neuropathy and confusion

Chromium excess
Not established

Requirements
Based on no evidence of beneficial effects associated with chromium intake in healthy subjects EFSA has not set up adequate Intake for chromium. In view of these limitations, the ICMR-2020 recommendation was adopted for Sri Lankan table.

Table 7.3.1: Chromium requirements in µg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	NA	NA
Children	1-3 years	Both	NA	NA	NA	NA
	4-10 years	Both	NA	NA	NA	NA
	11-17 years	Both	NA	NA	NA	NA
Adults	≥ 18 years	Both	NA	NA	50	NA
Pregnant women	All trimesters	Female	NA	NA	NA	NA
Lactating women	0-6 months postpartum	Female	NA	NA	NA	NA

Table 7.3.2: Sources of Chromium rich foods

Food	Cr content (mg)/100g	Serving size	Cr content (mg)/ serving
Mango-Karthakolomban	0.047	100g	0.047
Onion stalk	0.077	50g	0.038
Clam white shell (Kalapu bella)	0.123	30g	0.037
Amaranth spinous (Katu thampala)	0.037	50g	0.018
Marlin (Koppara malu)	0.06	30g	0.018
Amaranth red (Rathu thampala)	0.028	50g	0.014
Raisins dried- black	0.035	30g	0.01

7.4) Copper

Physiological role and functions

- Copper is an essential micronutrient required for electron transfer processes.
- It is a central component of many enzymes, including those involved in neurotransmitter synthesis, deamination, iron metabolism, superoxide dismutation, energy metabolism, dopamine to noradrenaline conversion, collagen and elastin cross-linking, and melanin synthesis.

Copper deficiency

- Clinical symptoms of copper deficiency are not common in humans and generally are seen as a consequence of mutations in the genes involved in copper metabolism (Menkes disease).
- Symptoms include:
  - normocytic and hypochromic anaemia, that is not responsive to iron supplementation
  - neurological findings, most commonly due to neuromyelopathy (human swayback)
  - increased risk of aneurysm as a consequence of impaired collagen and elastin synthesis
  - skin and hair hypopigmentation
  - leukopenia, neutropenia, hypercholesterolaemia,
  - myelodysplasia
  - alterations in immune function.

Copper excess

Liver function

Requirements

Based on EFSA recommendation depend on plasma copper, serum ceruloplasmin and platelet copper.

Table 7.4.1: Copper requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	0.4	ND
Children	1-3 years[1]	Both	NA	NA	0.7	1
	4-10 years	Both	NA	NA	1	2
	7-10 years[2]		NA	NA	1	3
	11-17 years	Male	NA	NA	1.3	4
		Female	NA	NA	1.1	4
Adults	≥ 18 years	Male	NA	NA	1.6	5
	≥ 18 years	Female	NA	NA	1.3	5
Pregnant women	All trimesters	Female	NA	NA	1.5	ND
Lactating women	0-6 months postpartum	Female	NA	NA	1.5	ND

([1,2]EFSA recommended 1-2 years for 1-3 years and 7-9 years were taken for 7-10 years)

Table 7.4.2: Sources of Copper rich foods

Food	Cu content (mg)/100g	Serving size	Cu content (mg)/serving
Octopus	6.72	30g	2
Beef liver	3.63	30g	1.1
Baby shrimps	3.54	15g	1.06
Eel	2.72	30g	0.82
Cashew nut	2.33	15g	0.7
Kottamba	2.13	15g	0.64
Crab mud (Kalapu kakuluwa)	123	30g	0.37
Squid long barrel (Bothal dalla)	1.1	30g	0.33
Gingerly -brown	1.92	15g	0.29
Crab (Muhudu kakuluwa)	0.84	30g	0.25
Gingerly -black	1.6	15g	0.24

7.5) Fluoride

Physiological role and functions
• Fluoride is not an essential nutrient. • A lack of fluoride intake during development will not alter tooth development but may result in increased susceptibility of enamel to acid attacks after eruption.
Fluoride deficiency
• Caries is not a fluoride deficiency disease.
Fluoride excess
Bone fracture
Requirements
Based on EFSA recommended of adequate Intake (AI) of 0.05 mg/kg body weight per day and the beneficial effect of dietary fluoride on the prevention of caries. The AI covers fluoride intake from all sources, including non-dietary sources such as toothpaste and other dental hygiene products.

Table 7.5.1: Fluoride requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	0.4	ND
Children	1-3 years	Both	NA	NA	0.6	1.5
	4-6 years	Male	NA	NA	1	2.5
		Female	NA	NA	0.9	2.5
	7-10 years[1]	Male	NA	NA	1.5	2.5
		Female	NA	NA	1.4	2.5
	11-14 years	Male	NA	NA	2.2	5
		Female	NA	NA	2.3	5
	15-17 years	Male	NA	NA	3.2	7
		Female	NA	NA	2.8	7
Adults	≥ 18 years	Male	NA	NA	3.4	7
	≥ 18 years	Female	NA	NA	2.9	7
Pregnant women	All trimesters	Female	NA	NA	2.9	7
Lactating women	0-6 months postpartum	Female	NA	NA	2.9	7

([1,2]EFSA recommended 7-8 years was taken for 7-10 years)

Table 7.5.2: Sources of Fluoride rich foods

Food	fluoride content µg /100g	Serving size	Fluoride µg / serving
Black tea, brewed (tap water)	-	1 cup	884
coffee, brewed (tap water)	-	1 cup	161
Raisins	233.9	30g	60.8
crab	209.9	30g	59.5
Shrimp	201	30g	57

7.6) Iodine

Physiological role and functions
• Iodine is an essential nutrient required as a mandatory structural and functional element of thyroid hormones. • The function of the thyroid hormones T3 and T4 encompasses the regulation of mitochondrial energy metabolism as well as cellular oxidation, thermoregulation, intermediate metabolism, carbohydrate, lipid and protein metabolism and nitrogen retention. • They are particularly necessary during early growth, development and maturation of most organs. • The target organs are, in particular, the developing brain, affecting the development of hearing and vision, muscles, the heart, the pituitary gland, the kidney, the reproductive system, and the bones. • According to their thyroid function, individuals are classified as euthyroid (i.e. having normal thyroid function), hypothyroid or hyperthyroid.

Iodine deficiency
• Various mechanisms can lead to thyroid disorders, and hypo- and hyperthyroid status can be observed in cases of both insufficient and excessive iodine intakes. • goitre.

Iodine excess
Changes in thyroid hormones

Requirements
Based on EFSA recommendation of the thyroid accumulation and turn over.

Table 7.6.1: Iodine requirements in µg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	70	NA	NA	ND
Children	1-3 years	Both	90	NA	NA	200
	4-6 years	Both	90	NA	NA	250
	7-10 years	Both	90	NA	NA	300
	11-14 years	Both	120	NA	NA	450
	15-17 years		130	NA	NA	500
Adults	≥ 18 years	Both	150	NA	NA	600
Pregnant women	All trimesters	Female	200	NA	NA	600
Lactating women	0-6 months postpartum	Female	200	NA	NA	600

Table 7.6.2: Sources of Fluoride rich foods

Food	Iodine content (µg) /100g	Serving size	Iodine (µg)/serving
seaweed, dried	2320	1 TBS, flaked 5 g	116.0
Milk, whole	34	240 ml	83.7
Yogurt	43	1 cup – 90 g	38.7
Cheese, Swiss	120	1 slice 30 g	36.0
Egg, whole, raw, fresh	49	50-60 g	24.6

7.7) Iron

Physiological role and functions

- Iron is necessary for most, if not all, pathways for energy and substrate metabolism.
- Globinhaems are transporters of oxygen, carbon dioxide, carbon monoxide and nitric oxide, stores of oxygen and scavengers of free radicals.
- The cytochrome P-450 oxidase system embraces over 11,000 diverse activities including the metabolism of endogenous substrates such as organic acids, fatty acids, prostaglandins, steroids and sterols including cholesterol and vitamins A, D and K.
- The citric acid cycle and respiratory chain involves six different haem proteins and six iron-sulphur clusters.
- The main components of the body that contain iron are erythrocyte haemoglobin and muscle myoglobin, liver ferritin, and haem and non-haem enzymes.
- Dietary iron requirements vary depending on inhibitors and enhancers of iron absorption in the same meal.

Iron deficiency

- Symptoms include:
  - Iron deficiency anaemia (a microcytic anaemia with haemoglobin concentrations below normal).
    - Women with high menstrual losses are at risk of developing iron deficiency.
  - Iron deficiency is a risk factor for increased blood concentrations of cadmium.
  - spoon-shaped nails,
  - soft nails,
  - glossitis,
  - cheilitis (dermatitis at the corner of the mouth),
  - mood changes,
  - muscle weakness and
  - impaired immunity.

Iron excess

Gastrointestinal distress

Requirements

Based on EFSA recommendation of factorial approach. ARs for iron in 3 general types of diets were considered: low absorption (5%) from an unrefined diet, moderate absorption (10%) from a diet with some meat/fish and moderate phytate, and high absorption (16%) from a diet with higher intake of meat/fish and lower phytate. Considering the mixed diet consumed by the Sri Lankans, moderate absorption (10%) was taken to estimate ARs.

Table 7.7.1: Iron requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	8	11	NA	ND
Children	1-3 years	Both	5	7	NA	ND
	4-6 years	Both	5	7	NA	ND
	7-10 years[1]	Both	8	11	NA	ND
	11-17 years[2]	Male	8	11	NA	ND
		Female	7	13	NA	ND
Adults	18-40 years	Male	6	11	NA	ND
		Female	7	16	NA	ND
	≥ 40 years	Male	6	11	NA	ND
		Female	6	11	NA	ND
Pregnant women	All trimesters	Female	7	16	NA	ND
Lactating women	0-6 months postpartum	Female	7	16	NA	ND

([1,2]EFSA recommended 7-11 years for 7-10 years and 12-17 years were taken for 11-17 years)

Table 7.7.2: Sources of Iron rich foods

Food	Fe content/ 100g (mg)	Serving size	Fe content/ serving (mg)
Beef liver	17.95	30g	5.38
Amaranth green (Katu thampala)	7.53	50g	3.76
Amaranth red (Rathu thampala)	7.25	50g	3.62
Chicken liver	9.92	30g	2.98
Gingerly seeds brown	15.93	15g	2.38
Gingerly seeds black	15.42	15g	2.31
Lentil dhal	7.45	20g	1.49

7.8) Magnesium

Physiological role and functions

- Magnesium is a cofactor of more than 300 enzymatic reactions.
- It is essential in the intermediary metabolism for the synthesis of carbohydrates, lipids, nucleic acids and proteins, as well as for specific actions in various organs such as the neuromuscular or cardiovascular system.
- Magnesium can interfere with calcium at the membrane level or bind to membrane phospholipids, thus modulating membrane permeability and electrical characteristics.
- Magnesium has an impact on bone health through its role in the structure of hydroxyapatite crystals in bone.
- Magnesium deficiency can have many different causes, including renal and gastrointestinal dysfunctions.
- Magnesium absorption takes place in the distal intestine, mainly as the ionised form.
- Percentage absorption is generally considered to be 40–50%.
- Magnesium absorption can be inhibited by phytic acid and phosphate and enhanced by the fermentation of soluble dietary fiber.

Magnesium deficiency

- Owing to the widespread involvement of magnesium in numerous physiological functions and the metabolic interactions between magnesium and other minerals, it is difficult to relate magnesium deficiency to specific symptoms such as
    - neuromuscular irritability,
    - muscle tremors and cramps,
    - fasciculation,
    - wasting and weakness,
    - restless leg syndrome,
    - fibromyalgia, i.e. conditions where the use of magnesium supplementation has led to inconsistent results.
- Magnesium deficiency can cause hypocalcaemia and hypokalaemia, leading to neurological or cardiac symptoms when it is associated with marked hypomagnesaemia (< 0.5 mmol/L).

Magnesium excess

Mild diarrhoea

Requirements

Based on EFSA recommendation of balance studies.

Table 7.8.1: Magnesium requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	80	ND
Children	1-3 years[1]	Both	NA	NA	170	ND
	4-10 years[2]	Both	NA	NA	230	250
	11-17 years	Male	NA	NA	300	250
		Female	NA	NA	250	250
Adults	≥ 18 years	Male	NA	NA	350	250
		Female	NA	NA	300	250
Pregnant women	All trimesters	Female	NA	NA	300	250
Lactating women	0-6 months postpartum	Female	NA	NA	300	250

([1,2]EFSA recommended 1-2 years for 1-3 years and 4-9 years for 4-10 years were taken)

Table 7.8.2: Magnesium rich food sources

Food	Content (mg) /100g	Serving size	Content (mg)/serving
Gingerly seed	419	15 g (1 TBS)	62.8
maize	139	20g(raw), 3TBS (cooked)	60
Baby shrimps	319	15g (1TBS)	47.8
cowpea	213	20g(raw), 3TBS (cooked)	42.6
Cashew	272	15 g (1TBS)	40.8
Ground nut	200	15 g (1TBS)	30
kottamba	123	15 g (1 TBS)	18.45
sprats	162	15g	12.1

7.9) Manganese

Physiological role and functions
• Manganese is a component of metalloenzymes such as superoxide dismutase, arginase and pyruvate carboxylase, and is involved in amino acid, lipid and carbohydrate metabolism. • Absorption of manganese in the intestine is low (< 10%).

Manganese deficiency
• Evidence of manganese deficiency in humans is poor. • A specific deficiency syndrome has not been described in humans. • A depletion-repletion study indicated that fleeting dermatitis and miliaria crystallina are deficiency signs.

Manganese excess
Neurotoxicity

Requirements
AI was adopted from EFSA recommendation.

Table 7.9.1: Manganese requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	0.02-0.5	ND
Children	1-3 years	Both	NA	NA	0.5	ND
	4-6 years	Both	NA	NA	1	ND
	7-10 years	Both	NA	NA	1.5	ND
	11-14 years	Both	NA	NA	2	ND
	15-17 years	Both	NA	NA	3	ND
Adults	≥ 18 years	Both	NA	NA	3	ND
Pregnant women	All trimesters	Female	NA	NA	3	ND
Lactating women	0-6 months postpartum	Female	NA	NA	3	ND

Table 7.9.2: Manganese rich food sources

Food	Mn content /100g (mg)	Serving size	Mn content /serving (mg)
Ash Plantain peels	53.52	15g	8.03
Water spinach	3.23	50g	1.61
Abul banana ripe	1.5	100g	1.5
Amaranth leaves red	2.15	50g	1.02
Amaranth – green	1.61	50g	0.8

7.10) Molybdenum

Physiological role and functions
• Molybdenum is an essential component of certain enzymes that catalyse redox reactions and contain, in addition to molybdenum, other prosthetic groups such as flavin adenine dinucleotide or haem (EFSA 2019). • In humans, sulphite oxidase, xanthine oxidoreductase, aldehyde oxidase and mitochondrial amidoxime reducing component require molybdenum linked with a pterin (molybdopterin) as the cofactor. • These enzymes are involved in the metabolism of aromatic aldehydes and the catabolism of sulphur containing amino acids and heterocyclic compounds, including purines, pyrimidines, pteridine and pyridines.
Molybdenum deficiency
• Clinical signs of molybdenum deficiency in healthy humans have not been observed. • A syndrome suggestive of dietary molybdenum deficiency was reported in one 24-year-old male patient with Crohn's disease and short bowel syndrome, who had used total parenteral nutrition for 12 months. • Deficiency of all molybdoenzymes occurs in people with molybdenum cofactor deficiency, a rare autosomal recessive syndrome with a defective hepatic synthesis of molybdenum cofactor. This genetic defect, for which three subtypes are known according to the gene affected, has been found in a variety of ethnic groups and all over the world. It is associated with: o feeding difficulties and seizures starting shortly after birth, o neurological and developmental abnormalities, o mental retardation, o encephalopathy, o ectopy of the lens and o usually death at an early age
Molybdenum excess
Reproductive toxicity
Requirements
Based on EFSA recommendation with balance study.

Table 7.10.1: Molybdenum requirements in µg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	10	ND
Children	1-3 years	Both	NA	NA	15	100
	4-6 years	Both	NA	NA	20	200
	7-10 years	Both	NA	NA	30	250
	11-14 years	Both	NA	NA	45	400
	15-17 years	Both	NA	NA	65	500
Adults	≥ 18 years	Both	NA	NA	65	600
Pregnant women	All trimesters	Female	NA	NA	65	600
Lactating women	0-6 months postpartum	Female	NA	NA	65	600

Table 7.10.2: Molybdenum (Mo) rich food sources

Food	Mo content (mg)/100g	Serving size	Mo content (mg)/serving
Apple green	0.839	50g	0.42
Bael fruit	0.819	50g	0.41
Cowpea white	0.226	20g	0.05
Amaranth spinosus	0.04	50g	0.02

7.11) Phosphorus

Physiological role and functions

- Phosphorus is involved in many physiological processes, such as in the cell's energy cycle, in regulation of the body's acid–base balance, as a component of the cell structure, in cell regulation and signalling, and in the mineralisation of bones and teeth.
- About 85% of the body's phosphorus is in bones and teeth, 14% is in soft tissues, including muscle, liver, heart and kidney, and only 1% is present in extracellular fluids.

Phosphorus deficiency

- Phosphorus deficiency presents as hypophosphataemia, i.e. serum phosphorus concentrations below 0.80 mmol/L in adults. This occurs only rarely because of inadequate dietary phosphorus intake and is almost always due to metabolic disorders.
- The incidence of hypophosphataemia is high in certain subgroups of patients, such as those with sepsis, chronic alcoholism, major trauma or chronic obstructive pulmonary disease, and may also develop in kidney patients.
- Hypophosphataemia may also occur during the management of diabetic ketoacidosis.
- Mild hypophosphataemia can also occur as a common, generally asymptomatic, consequence of hyperparathyroidism.
- Clinical symptoms of hypophosphataemia (serum phosphorus concentrations fall below 0.3 mmol/L) include:
    - anorexia,
    - anaemia,
    - muscle weakness,
    - bone pain,
    - rickets and osteomalacia,
    - increased susceptibility to infection,
    - paraesthesia,
    - ataxia,
    - confusion and even death

Phosphorus excess

Elevated serum phosphate

Requirements

Based on IOM recommendation considering serum phosphate level

Table 7.11.1: Phosphorus requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	160	ND
Children	1-3 years	Both	NA	NA	250	ND
	4-10 years	Both	NA	NA	440	ND
	11-17 years	Both	NA	NA	640	ND
Adults	≥ 18 years	Both	NA	NA	550	ND
Pregnant women	All trimesters	Female	NA	NA	550	ND
Lactating women	0-6 months postpartum	Female	NA	NA	550	ND

Table 7.11.2: Phosphorus (P) rich food sources

Food	P content /100g (mg)	Serving size	P content /serving (mg)
Powdered cow s milk - skim	956	30g	286
Goat milk-whole	111	240ml	260
Cow s milk liquid-low fat	106	240ml	250
Cow s milk liquid-FCM	90	240ml	200
Powdered cow s milk - FCM	758	30g	226
Cheese cheddar	556	25g	139
Egg yolk	561	20g	112
Gingerly seeds - black	699	15g	105
Gingerly seeds- brown	682	15g	102
Cottage Cheese Paneer	414	25g	103
Beef liver	326	30g	98
Seer fish	302	30g	91
Kottamba	548	15g	82
Cashew nuts	537	15g	80
Baby shrimps	532	15g	78

7.12) Potassium

Physiological role and functions

- Potassium is an essential mineral in the human diet.
- It is the predominant osmotically active element inside cells.
- It plays a major role in the distribution of water inside and outside cells, assists in the regulation of the acid–base balance, and contributes to establishing a membrane potential which supports electrical activity in nerve fibres and muscle cells.
- Potassium has a role in cell metabolism, participating in energy transduction, hormone secretion, and the regulation of protein and glycogen synthesis.

Potassium deficiency

- Potassium deficiency, presenting as hypokalaemia, is defined as a serum potassium concentration lower than 3.5 mmol/L.
- In general, deficiency may be caused by increased potassium losses via diarrhoea, vomiting, burns or excessive renal losses (owing, for example, to renal tubular acidosis, high secretion of mineralocorticoids, some diuretics) leading to low total body potassium.
- Hypokalaemia can also occur when total body potassium is normal in case of an intracellular shift of potassium.
- The most important causes of an intracellular shift include alkalosis, insulin excess, catecholamine excess and the genetic disease called familial periodic paralysis.
- Hypokalaemia resulting from insufficient dietary intake is rare and may be associated with severe hypocaloric diets or occur as the result of an increased requirement needed for the synthesis of new tissue (e.g. muscle) during recovery from malnutrition.
    - polyuria,
    - muscle weakness,
    - decreased peristalsis possibly leading to intestinal ileus,
    - mental depression and respiratory paralysis in severe cases.
- Hypokalaemia is generally associated with increased morbidity and mortality, especially from cardiac arrhythmias or sudden cardiac death.

Potassium excess

Not established

Requirements

Based on EFSA recommendation of beneficial effect on blood pressure in adults with potassium intake of 3,500 mg/day and considering consistent evidence that potassium intakes below 3,500 mg/day are associated with a higher risk of stroke.

Table 7.12.1: Potassium requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	750	ND
Children	1-3 years	Both	NA	NA	800	ND
	4-6 years	Both	NA	NA	1100	ND
	7-10 years	Both	NA	NA	1800	ND
	11-14 years	Both	NA	NA	2700	ND
	11-17 years	Both	NA	NA	3500	ND
Adults	≥ 18 years	Both	NA	NA	3500	ND
Pregnant women	All trimesters	Female	NA	NA	3500	ND
Lactating women	0-6 months postpartum	Female	NA	NA	4000	ND

Table 7.12.2: Potassium rich food sources

Food	Potassium (mg) / 100 g	Serving size	Potassium (mg) /serving
Coconut water (Thambili)	304	200ml	608
Anamalu	449	90g	404
Wild yam	740	45g	333
Amaranth, green	623	50g	280
White cowpea	1243	50g	279
Lotus root	611	50g	275
Ambul banana	437	60g	262
Whole green gram	1127	45g	253
Lasia stalk	560	45g	252
Shark	837	30g	251
Cassava leaves	500	45g	225
Pistachio nuts	1050	15g	157

7.13) Selenium

Physiological role and functions
• A total of 25 selenoproteins with a variety of functions, including antioxidant effects, T-cell immunity, thyroid hormone metabolism, selenium homeostasis and transport, and skeletal and cardiac muscle metabolism. • Selenoprotein P (SEPP1) plays a central role in selenium supply to tissues and participates in the regulation of selenium metabolism in the organism.

Selenium deficiency
• Muscle weakness, fatigue, hair loss, infertility subfertility, weakened immune system

Selenium excess
Selenosis – loss of hair and nails

Requirements
Based on EFSA recommendation of plasma glutathione peroxidase activity.

Table 7.13.1: Selenium requirements in μg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	NA	NA	15	ND
Children	1-3 years	Both	NA	NA	15	60
	4-6 years	Both	NA	NA	20	90
	7-10 years	Both	NA	NA	35	130
	11-14 years	Both	NA	NA	55	200
	15-17 years	Both	NA	NA	70	250
Adults	≥ 18 years	Both	NA	NA	70	300
Pregnant women	All trimesters	Female	NA	NA	70	300
Lactating women	0-6 months postpartum	Female	NA	NA	85	300

Table 7.12.2: Selenium rich food sources

Food item	Se content (μg)/100 g	Serving size	Se content (μg)/serving
Queenfish	736	15 g	110.4
Baby shrimps	735	1 TBS	110.2
Skipjack tuna	624	15 g	93.60
Beat greens	65.92	3 TBS	59.30
Sardinella, goldstrip	154	30 g	46.20
Sardinella, spotted	113	30 g	33.90
Scad, mackeral	95.08	30 g	28.50
Wheat, flour, atta	60.32	3 TBS	27.14
Lentil. dhal	69.26	3 TBS	15.60
Peas, dry	50.51	3 TBS	11.36

7.14) Sodium

Physiological role and functions
• Sodium (Na+) is the dominant cation in the extracellular fluid (ECF) of the body. • The functions of sodium lie in its participation in the control of the volume and systemic distribution of total body water; enabling the cellular uptake of solutes; and the generation via interactions with potassium of transmembrane electrochemical potentials.

Sodium deficiency
• Nausea, headache, confusion, Loss of energy, fatigue, Spasms, muscle cramps, seizures, coma

Sodium excess
Not established

Requirements
Based on EFSA recommended AI.

Table 7.14.1: Sodium requirements in g/day

	Age	Sex	AR	RDA	AI/RI/safe & adequate intake	UL
Infants	7-11 months	Both	NA	NA	0.2	NA
Children	1-3 years	Both	NA	NA	1.1	NA
	4-6 years	Both	NA	NA	1.3	NA
	7-10 years	Both	NA	NA	1.7	NA
	11-17 years	Both	NA	NA	2	NA
Adults	≥ 18 years	Both	NA	NA	2	NA
Pregnant women	All trimesters	Female	NA	NA	2	NA
Lactating women	0-6 months postpartum	Female	NA	NA	2	NA

Table 7.12.2: Foods rich in sodium

Food	Na content (mg)/100g	Serving size	Na content (mg)/serving
Marlin, Indo-pacific sailfish, dry	13730	15g	2060
Queen fish dry	13679	15g	2052
Smooth belly sardinella dry	13018	15g	1953
Sprats	10921	15g	1638
Shark dry	10585	15g	1588
Baby shrimps	9146	15g	1372
Skipjack tuna dry	7909	15g	1186
Maldives fish dry	10612	5g	530
Cheddar cheese	1304	25g	326
Prawn giant	849	30g	255
Cottage Cheese paneer	509	25g	127
Salted butter	714	15g	107

7.15) Zinc

Physiological role and functions

- Zinc has a wide array of vital physiological functions.
- It has a catalytic role in each of the six classes of enzymes.
- The human transcriptome has 2,500 zinc finger proteins, which have a broad intracellular distribution and the activities of which include binding of RNA molecules and involvement in protein–protein interactions.
- Thus, their biological roles include transcriptional and translational control/modulation and signal transduction.

Zinc deficiency

- Clinical features of zinc deficiency are non-specific.
- Infants with acrodermatitis enteropathica - severe zinc deficiency
- Mild to moderate dietary zinc depletion is a cause of several non-specific features including
    - growth retardation,
    - depressed immune function with susceptibility to infections,
    - delayed wound healing,
    - loss of appetite and loss of cognitive function.
- Severe restriction of dietary zinc is a cause of other clinical features including skin rashes.
- Acute acquired zinc deficiency, primarily in patients dependent on intravenous nutrition lacking zinc.
- individuals with malabsorption syndromes including sprue, Crohn's disease, and short bowel syndrome are at risk of zinc deficiency due to malabsorption of zinc and increased urinary zinc losses.

Zinc excess

Copper status

Requirements

Based on EFSA recommendation of null balance. Zinc requirements vary depending on inhibitors (primarily phytate) in the same meal. Four levels of phytate intakes are considered: 300 mg phytate/d – refined diet (western diet), 600 mg phytate/d – semi-refined diet, 900 mg phytate/d, and - semi-unrefined diets, 1200 mg phytate/d in the diet - unrefined diets. Considering the mixed Sri Lankan diet, mainly it is semi-unrefined in nature, 900 mg phytate/d was taken to estimate AR.

Table 7.15.1: Zinc requirements in mg/day

	Age	Sex	AR	RDA	AI/RI	UL
Infants	7-11 months	Both	2.4	2.9	NA	ND
Children	1-3 years	Both	3.6	4.3	NA	7
	4-6 years	Both	4.6	5.5	NA	10
	7-10 years	Both	6.2	7.4	NA	13
	11-14 years	Both	8.9	10.7	NA	18
	15-17 years	Male	11.8	14.2	NA	22
		Female	9.9	11.9	NA	22
Adults	≥ 18 years	Male	11	14	NA	25
		Female	8.9	11	NA	25
Pregnant women	All trimesters	Female	10.2	12.6	NA	25
Lactating women	0-6 months postpartum	Female	11.3	13.9	NA	25

Table 7.12.2: Rich food sources of Zinc

Food	Zn content (mg)/100g	Serving size	Zn content (mg)/serving
Beef liver	6.72	30g	2
Goat Chops	5.05	30g	1.5
Gingerly seeds (white/black)	9	15g	1.35
Amaranth spinosus (Katu thampala)	2.09	50g	1.04
Beef chops	3.31	30g	0.99
Smooth belly sardinella, dry (Keeramin)	3.19	30g (~5 Keeramin)	0.96
Cottage cheese Paneer	3.55	25g	0.89
Cashew nuts	5.27	15g	0.79
Baby Shrimps	5.15	15g	0.77
Bengal gram dal (Kadala parippu)	3.65	20g(raw) 3TBS (cooked)	0.73
Lentil dal (Maisur parippu)	3.34	20g(raw) 3TBS (cooked)	0.714
Cowpea	3.57	20g(raw) 3TBS (cooked)	0.714

References

1. Institute of Medicine 2000. Dietary Reference Intakes: Applications in Dietary Assessment. Washington, DC: The National Academies Press. https://doi.org/10.17226/9956.
2. (Source: National academics of sciences, engineering, and medicine 2018. Harmonization of approaches to nutrient reference values)
3. EFSA (European Food Safety Authority), 2017. Dietary Reference Values for nutrients. Summary Report. EFSA supporting publication 2017:e15121. 98 pp. doi:10.2903/sp.efsa.2017.e15121.
4. Dietary protein quality evaluation in human nutrition Report of an FAO Expert Consultation 31 March–2 April, 2011 Auckland, New Zealand FAO FOOD AND NUTRITION PAPER 92 FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS ROME, 2013.
5. Lindsay H Allen, Alicia L Carriquiry, Suzanne P Murphy, Perspective: Proposed Harmonized Nutrient Reference Values for Populations, Advances in Nutrition, Volume 11, Issue 3, May 2020, Pages 469–483, https://doi.org/10.1093/advances/nmz096
6. National Academics of Sciences, Engineering, and Medicine. 2018. Harmonization odf approaches to Nutrition reference values: Applications to young children and women of reproductive age. Washington, DC: The National Academies press. https://doi.org/10.17226/25148.
7. Health Council of the Netherlands. Dietary reference values for proteins. The Hague: Health Council of the Netherlands, 2021; publication no. 2021/10. www.healthcouncil.nl./Report-Dietary-reference-values-for-proteins.pdf
8. EFSA (European Food Safety Authority), 2017. Dietary Reference Values for nutrients. Summary Report. EFSA supporting publication 2017:e15121. 98 pp. doi:10.2903/sp.efsa.2017.e15121
9. Health Council of the Netherlands. An evaluation of the EFSA's dietary reference values (DRVs), Part 1. Dietary reference values for vitamins and minerals for adults. Background document to Voedingsnormen voor vitamines en mineralen voor volwassenen. The Hague: Health Council of the Netherlands, 2018; publication no. 2018/19A.
10. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA); Scientific Opinion on Dietary Reference Values for energy. EFSA Journal 2013;11(1):3005. [112 pp.] doi:10.2903/j.efsa.2013.3005. Available online: www.efsa.europa.eu/efsajournal
11. ICMR-NIN Expert Group on Nutrient Requirement for Indians, Recommended Dietary Allowances (RDA) and Estimated Average Requirements (EAR) - 2020.