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Swarup Kumar Chakrabarti *Editors*

Potato

Nutrition and Food Security

Springer

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Foreword

Potato (*Solanum tuberosum*) is the world's fourth most important food crop after maize, wheat and rice with 377 million tonnes of tubers produced from 19.2 million hectares of land, in over 160 countries, in 2016 (http://faostat.fao.org). Furthermore, as a result of steady increase in its demand in recent years, over 50% of production is now in Asia, with China and India the largest contributors. Harvestable potatoes are produced in 100 to 120 days, and therefore they proved suitable for double cropping and intercropping systems. Globally, its average dry weight yield (3.92 t/ha) compares favourably with the three cereals (3.88 t/ha) as a result of a higher harvest index of 0.75 compared with 0.5. Likewise, protein content at 10% of dry weight equals that of most cereals with protein quality better than most other non-animal sources. Hence, it was not entirely surprising that the United Nations named 2008 as the "International Year of the Potato", in recognition of its contribution as a major food staple to their Millennium Development Goals of providing food security and eradicating poverty. By 2015, however, out of a world population of 7.3 billion, around 800 million people still suffered from hunger and more than 2 billion from one or more micronutrient deficiencies, known as "hidden hunger", especially in women, infants and children. Ironically, about 1.9 billion people were overweight, of whom 600 million were obese. In this context, potato needs to be appreciated as more than a major supplier of carbohydrate (starch) in the human diet. It also provides significant amounts of protein, minerals, vitamins, micronutrients and phytonutrients, which include antioxidants, is high in dietary fibre and virtually free of fat and cholesterol. Hence, potato has an important role to play in the United Nations "2030 Agenda for Sustainable Development" that started on 1 January 2016. By 2030, the aim is to "ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round". By then, the world population is expected to reach 8.5 billion and continue to increase to 9.7 billion in 2050, when it will also have experienced significant climate change. For potatoes, the need is to improve nutritional value and to increase sustainable production and adaptation to environmental change.

This book "Potato: Nutrition and Food Security" deals with the role of potatoes in the human diet, discusses the status of various nutritional compounds, along with the methods for their evaluation and their health benefits, and suggests genetic modifications to enhance the concentration of health-promoting compounds. The nutritional significance of current and new potato products is also discussed. I really appreciate the efforts made by the team of ICAR-Central Potato Research Institute (CPRI), Shimla, India, in compiling this book to provide the latest knowledge on the nutritional quality of potatoes to consumers and all the stakeholders. I have followed with great interest the work of CPRI since attending my first Global Conference on Potato in New Delhi in 1999 and feel a certain affinity with the organization that like me was born in 1949. I am sure that this book will help to establish the nutritional significance of potatoes internationally and hence increase the appreciation of potatoes as a highly nutritious food.

The James Hutton Institute
Dundee, UK
8 June 2020

John E. Bradshaw

Preface

Food security in a broader way may be realized when all people at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life. Food security depends on the availability of food, affordability and proper utilization of food. Food and Agriculture Organization (FAO 2008) has emphatically considered and recommended potato as a potential crop for the poorest of the poor, to ensure global food, nutritional and income security in the future. Potato is a flexible crop compared to other vegetables and can be grown under conditions where other crops may fail to grow. Moreover, its short and flexible life cycle brings the yield within 100 to 120 days, and hence it is also suitable for double cropping and intercropping systems. Potato is a good option for food and is capable of producing nutritious food more quickly on lesser land compared to any other major food crops. It yields more edible energy, protein and dry matter per unit area and time compared to other crops due to its high protein–calorie ratio (17 g protein: 1000 kcal) and short life cycle. Farmers can harvest up to 80% of biomass as edible, nutritious food in case of potato, whereas in case of cereals only up to 50% can be harvested as grains. Serious food security problems are envisaged for the future due to stagnation of crop yields, exhausting soils and increasing population in the developing world. Besides, large-scale diversion of food grains to feed and bio-fuel and expected steep rise in per capita consumption of pulses, edible oil, fruits and vegetables, milk, sugar and non-vegetarian foods in the regime of steadily rising population are bound to put pressure on existing cultivable land. Since cultivable land is expected to remain more or less constant, the role of crops such as potato having higher production per unit land and time will become imperative. This way potato crop has a very high probability of making a crucial contribution to future food security.

Potato is known to everyone as a supplier of energy, but its ability to supply vital nutrients is vastly underestimated. Potato is an excellent source of complex carbohydrates, dietary fibres and vitamin C. It also contains a variety of health-promoting compounds, such as carotenoids, flavonoids, chlorogenic acid and caffeic acid, as well as unique tuber storage proteins, such as patatin, which exhibit activity against free radicals. Potato is also a substantial source of ascorbic acid, thiamine, niacin, pantothenic acid and riboflavin. Due to the nutritional value of potato, it is highly desirable in the human diet. This book in its 15 chapters elaborates the nutritional significance of potatoes. These chapters also suggest future strategies to further enhance the nutritional quality of potatoes. We sincerely believe that this book will help to establish the nutritional significance of potatoes. It will help to enhance the acceptance of potato as a staple crop due to the presence of a myriad of nutritional compounds in it. It is hoped that the contents of the book shall provide a platform for masses to understand the role of potatoes in food and nutritional security and also help in removing a few misconceptions associated with potato consumption.

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Pinky Raigond Scientist, Division of CPB & PHT, ICAR-Central Potato Research Institute has specialized in the area of Plant Physiology. She has significantly contributed in the area of nutritional quality of potatoes, identification/quantification of health promoting compounds in potatoes, development of antioxidant rich, low glycaemic and flavoured potatoes for speciality sector, processing industry waste utilization for development of eco-friendly nanoparticles, disposable biodegradable tableware and biodegradable active packaging films, processing technologies for the entrepreneurs and potato post harvest management. Her research work is published in high impact journals. She is recipient of 'Young Achievers' Award' and Young Woman Scientist Award.

Brajesh Singh Principal Scientist & Head, Division of CPB & PHT, ICAR-Central Potato Research Institute has specialized in the area of Plant Physiology. He has made significant contribution in the area of development and refinement of potato storage technologies at farm and cold store level; processing technologies for the entrepreneurs; establishing the quality and nutritional laboratory; and development of protocols for nutritional profiling of potatoes. He is recipient of Associateship of National Academy of Agricultural Sciences and HSI-Dr. JC Anand Gold Medal for his work on Post-Harvest Technology. He is the Fellow of Indian Society for Plant Physiology, New Delhi; The Indian Academy of Horticultural Sciences, New Delhi; and Indian Potato Association, Shimla.

Som Dutt Principal Scientist, Division of CPB and PHT, ICAR-Central Potato Research Institute, has specialized in the area of Plant Biochemistry and Molecular Biology. During 2002–2014, he worked at CSIR-Institute of Himalayan Bioresource Technology as Scientist/Senior Scientist. He has made a significant contribution in the area of developmental biology of potato and important medicinal plants. He was awarded Junior Research Fellowship by ICAR during M.Sc. and Junior Research Fellowship/Senior Research Fellowship by CSIR during Ph.D. He was awarded Rothamsted International Fellowship for the year 2003–2004 by Rothamsted Internationals, Rothamsted Research, Harpenden, United Kingdom. He has published research work in high impact factor journals and has been associated with the development of important technologies that have been granted international patents.

Swarup Kumar Chakrabarti Former Director, ICAR-Central Potato Research Institute, Shimla and ICAR-CTCRI, Thiruvananthapuram has specialization in the area of genomics, molecular biology, and disease diagnostics. He made significant contribution in the area of potato structural and functional genomics, linkage mapping, marker assisted selection; development of transgenics; and plant disease diagnosis. He is the recipient of Shri L.C. Sikka Endowment Award of NAAS, Dr. S. Ramanujam Award of ICAR-CPRI, IPA-Kaushalaya Sikka Memorial Award, Biotechnology Overseas Associateship DBT, Dr. J.P. Verma Memorial Award, Indian Phytopathological Society and many others. He is the Fellow of National Academy of Agricultural Sciences, New Delhi; Indian Phytopathological Society, New Delhi; Indian Potato Association, Shimla; and Confederation of Horticultural Associations of India, New Delhi.

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Abbreviations

3GT	Flavonoid-3-*O*-glucosyltransferase
5-UGT	5-O-Glucosyltransferase
AA	Ascorbic acid
ACE	Angiotensin-converting enzyme
ACP	Acyl carrier protein
ADP	Adenosine diphosphate
AFLP	Amplified fragment length polymorphism
AH	Arogenate dehydro
AmA1	Amaranth seed albumin
AMD	Age-related macular degeneration
APCI	Atmospheric pressure chemical ionization
APPH	A potato protein hydrolysate
APPH	Alcalase-generated potato protein hydrolysate
APPI	Atmospheric pressure photoionization
ARPs	Ama1-responsive protein spots
AS	Anthranilate synthase
ASD	Aspartate-semialdehyde
ATP	Adenosine triphosphate
B	Boron
Bf.	*Bifidobacterium* spp.
BOD	Biological oxygen demand
Br	Bromine
BRCs	Biguanide and related compounds
Ca	Calcium
$CaCl_2$	Calcium chloride
CAGR	Compound annual growth rate
CAPS	Cleaved amplified polymorphic sequence
CbL	Cystathionine-lyase
CCD	Carotenoid cleavage dioxygenase
CCK	Cholecystokinin
cDNA	Complementary DNA
CER	Ceremix 2XL
CGA	Chlorogenic acids

CGIAR	Consultative Group on International Agricultural Research
CgS	Cystathionine-synthase
CHI	Chalcone isomerase
CHS	Chalcone synthase
chuPCI	Cystine-knot metallocarboxypeptidase inhibitor
CHY-β	β-Carotene hydroxylase
CHY-ε	ε-Ring hydroxylase
CID	Collision-induced dissociation
Cl	Chlorine
CNS	Central nervous system
Co	Cobalt
CoA	Coenzyme A
CP	Crude protein
CPC	Centrifugal partition chromatography
CPRI	Central Potato Research Institute
CQAs	Caffeoylquinic acids
CRC	Colorectal cancer
CrtB	Phytoene synthase
CrtI	Phytoene desaturase/carotene isomerase
CRTISO	Carotenoid isomerase
CrtY	Lycopene beta-cyclase
Cu	Copper
CysTA	Cystathionine
DAD	Diode array detection
DAG	Diacylglycerol
DAHPS	DAHP synthase
DAP	Diaminopimelate
DAPAE	DAP epimerase
DAPAT	DAP-aminotransferase
DEP	Depol 670L
DESI-MS	Desorption electrospray ionization mass spectrometry
DF	Dietary fibre
DFR	Dihydroflavonol reductase
DGAT	Diacylglycerol acyltransferase
DHDP	Dihydrodipicolinate
DHDPS	Dihydrodipicolinate synthase
DHF	7,8-Dihydrofolate
DM	Diabetes mellitus
DOS	Days of storage
DRV	Daily requirement values
DW	Dry weight
EAE	Enzyme-assisted extraction
EAR	Estimated average requirement
ECD	Electrochemical detectors
ELISA	Enzyme-linked immunosorbent assay

ER	Endoplasmic reticulum
ESI	Electrospray ionization
ESI/MS	Electrospray ionization/mass spectrometry
EU	European Union
FAMEs	Fatty acid methyl esters
FAO	Food and Agriculture Organization
FAS	Fatty acid synthase
Fas-FADD	Fas-associated death domain
Fe	Iron
FFA	Free fatty acid
FODMAPs	Fermentable oligo-, di- and monosaccharides and polyols
FT	Fourier transform
FW	Fresh weight
GAE	Gallic acid equivalent
GALDH	L-Galactono-1,4-lactone dehydrogenase
GalUR	D-Galacturonate reductase
GBBS	Granule bound starch synthase
GBS	Genotyping by sequencing
GC/MS	Gas chromatography/mass spectrometry
GC-MS	Gas chromatography-mass spectrometry
GGPP	Geranylgeranyl diphosphate
GGPS	Geranylgeranyl pyrophosphate synthase
GI	Glycemic index
GL	Glycolipids
GPAT	*sn1*-Glycerol-3-phosphate acyltransferase
GPP	Geranyl pyrophosphate
GRAS	Generally regarded as safe
GSN	Gelsolin
GWD	α-Glucan water dikinase
H_2O_2	Hydrogen peroxide
HA	Haemagglutination
HCD	Higher energy collision-induced dissociation
HcY	Homocysteine
HDH	Homoserine dehydrogenase
HDL	Non-high-density lipoprotein
HFD	High fat diet
HG	High glucose
HM	Homocysteine methyltransferase
HNO_3	Nitric acid
HPLC	High-pressure liquid chromatography
HPLC-PDA	High-pressure liquid chromatography with a photodiode array detector
HPP	High-pressure processing
HPPD	p-Hydroxyphenylpyruvate dioxygenase

HPT	Homogentisate phytyl transferase
HPTLC	High-performance thin-layer chromatography
HS	Homoserine
HSK	Homoserine kinase
I^-	Iodide
I	Iodine
iAUC	Incremental area under curve
IBS	Irritable bowel syndrome
ICAPES	Inductively coupled argon plasma emission spectrophotometer
IGPS	Indole-3-glycerol phosphate synthase
IO^{3-}	Iodate
IPI	Isopentenyl pyrophosphate isomerise
IRT	Iron-regulated transporter
ISFET	Ion-sensitive field-effect transistor
K	Potassium
KASII	3-Ketoacyl-ACP synthases II
kDa	Kilo Dalton
kg/ha	Kilogram per hectare
KTI	Kunitz-type inhibitors
L	*Lactobacillus* spp.
LAB	Lactic acid bacteria
LC-MS	Liquid chromatography-mass spectrometry
LC-NMR	Liquid chromatography-tandem nuclear magnetic resonance
LCY-β	Lycopene β-cyclase
LCY-ε	Lycopene ε-cyclase
LD	Lipid droplet
LDAP	Lipid droplet-associated protein
LDL	Low-density lipoprotein
LPAAT	Lysophosphatidic acid acyltransferase
LWM	Low-molecular weight
MAE	Microwave-assisted extraction
MAGIC	Multiparent advanced generation intercross
MALDI-TOF	Matrix-assisted laser desorption/ionization-time of flight
MALDI-TOFMS	Matrix-assisted laser desorption ionization-time of flight mass spectrometry
MAS	Marker-assisted selection
MASL	Mean above sea level
Mg	Magnesium
mg/100 g FW	Milligram per 100-gram fresh weight
mg/kg	Milligram per kilogram
MGL	Methionine gamma-lyase
min	Minutes
Mn	Manganese
MS	Mass spectrometer
MT	Metric tons

MUFAs	Monounsaturated fatty acids
MW	Molecular weight
N	Nitrogen
Na	Sodium
NaCl	Sodium chloride
NAD	Nicotinamide adenine dinucleotide
NADP	Nicotinamide adenine dinucleotide phosphate
NADPH	Nicotinamide adenine dinucleotide phosphate
NCED	9-Cis-epoxycarotenoids dioxygenase
Ni	Nickel
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
NIH	National Institutes of Health
NIRS	Near-infrared spectroscopy
NL	Neutral lipids
NMR	Nuclear magnetic resonance
NO	Nitric oxide
NTDs	Neural tube defects
NXS	Neoxanthin synthase
OPH	O-Phospho-homoserine
P	Phosphorus
PA	Phosphatidic acid
PAI	Phosphoribosyl anthranilate isomerase
PAL	Phenylalanine ammonia-lyase
PAT	Phosphoribosylanthranilate transferase
Pb	Lead
PC	Phosphatidylcholine
PDA	Photodiode array
PDI	Potato cathepsin D inhibitor
PDS	Phytoene desaturase
PE	Phosphatidylethanolamine
PEF	Pulsed electric field
pERK1/2	Phosphorylated extracellular signal-regulated kinases
PFE	Pressurized fluid extraction
PI	Protease inhibitors
PIN	Protease inhibitors I and II
PL	Phospholipid
PLP	Pyridoxal 5′-phosphate
PMC	Potato multicystatin
PSY	Phytoene synthase
PUFA	Polyunsaturated fatty acid
PWD	Phosphoglucan water dikinase
QSRs	Quick-service restaurants
QTLs	Quantitative trait loci
RAG	Rapidly available glucose

RDA	Recommended dietary allowances
RDS	Rapidly digestible starch
RFLP	Restriction fragment length polymorphism
RH	Relative humidity
RIL	Recombinant inbred line
ROS	Reactive oxygen species
RP-HPLC	Reverse-phase high-performance liquid chromatography
RS	Resistant starch
RSM	Response surface methodology
S	Sulphur
SAG	Slowly available glucose
SAH	S-Adenosylhomocysteine
SAM	S-Adenosyl methionine
SAMS	S-Adenosylmethionine synthetase
SAR	Structure–activity relationship
SCAR	Sequence characterized amplified region
SCFA	Short-chain fatty acids
SDSt	Slowly digestible starch
SDS	Sodium dodecyl sulphate
Se	Selenium
Si	Silicon
SNP	Single nucleotide polymorphism
STG1	Solanidine galactosyltransferase
STG2	Solanidine glucosyltransferase
STG3	Solanine rhamnosyl transferase
STZ	Streptozotocin
TAG	Triacylglycerol
TC	Tocopherol cyclase
TE	Triennium ending
TG	Triacylglycerol
THDP	Tetrahydrodipicolinate
THF	5,6,7,8-Tetrahydrofolate
TILLING	Targeting induced local lesion in genomes
TLC	Thin-layer chromatography
TPP	Thiamine pyrophosphate
TS	Thr synthase
UAE	Ultrasound-assisted extraction method
UPLC-DAD-MS	Ultra-high-performance liquid chromatography-diode array detector-tandem mass spectrometry
USA	United States of America
USDA	United States Department of Agriculture
UV/VIS	Ultraviolet/visible
VDE	Violaxanthin de-epoxidase
WHO	World Health Organization
ZDS	f-Carotene desaturase

ZEP	Zeaxanthin epoxidase
Zn	Zinc
ZRT	Zinc-regulated transporter

Potatoes for Food and Nutritional Security 1

Brajesh Singh, Pinky Raigond, Som Dutt, and Manoj Kumar

Abstract

Potatoes have been used as food since ages, however, investigations on its nutritional significance have increased its importance as alternative for both food and nutritional security. The global trend of potato production and per capita availability clearly indicates a decrease of production in developed world and accelerated growth in developing world including Asia and Africa. These two regions of the world also have higher number of undernourished, therefore, higher per capita availability of potatoes in these regions could substantiate the food and nutritional requirements of the populations. The chapter describes in brief, the nutritional significance of potatoes in terms of its energy value, carbohydrates, protein, vitamins, minerals and health-promoting compounds. The significance of all these compounds have been discussed in length under different chapters. It is hoped that the contents of the book shall provide a platform for masses to understand the role of potatoes in food and nutritional security and also help in removing few misconceptions associated with potato consumption.

Keywords

Food and nutrition · Dietary energy supply adequacy · Undernourishment · Birthweight

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1.1 Introduction

Potato is a wholesome food contributing to the energy and nutritional requirements of a large population world over. It has been used as a food by humans for almost 8000 years and it is believed that cultivated potato originated in South America, most likely near Lake Titicaca on the borders of Peru and Bolivia. When Spain conquered Peru, they took potatoes from there and spread it all over the Europe by the end of the sixteenth century. Further spread of potatoes was facilitated by several European countries including Portugal and Britain. However, its significance and role in the global food system is under-appreciated. Potatoes have been known for their use as staple food, cash crop, animal feed, and also as source of starch for industrial uses in almost 160 countries world over (Ramani and Mouille 2019).

Food security depends on availability of food, affordability and proper utilization of food. Generally it is considered that surplus food grains lead to nutritional security, but it is not always true to all the population, as affordability is one of the major issues. There are few other indicators of food and nutritional security as well like average dietary energy supply adequacy, proportion of undernourished population and low birthweight. Undernourished population and <5 years old underweight children are high in several Asian countries like Bangladesh and India with the status remaining alarming over the years (Singh et al. 2020). Globally India is second in child malnutrition after Bangladesh. In India still more than 40% children are underweight, which is of great concern. However, the rate of mortality of <5 years olds has decreased over the period, but it is still up to 6.3% in India (Singh et al. 2020). The average dietary energy supply adequacy has been found to be comparatively high in North America and Europe, low in Asia and least in Africa (Fig. 1.1). The prevalence of undernourishment though has decreased over last two decades, but still is high in Africa and Asia (Fig. 1.2). Similarly, low birthweight has also decreased over the calculated period, but again is alarming in Asia (Fig. 1.3). FAO data suggests that about 11 percent of the population is undernourished, which

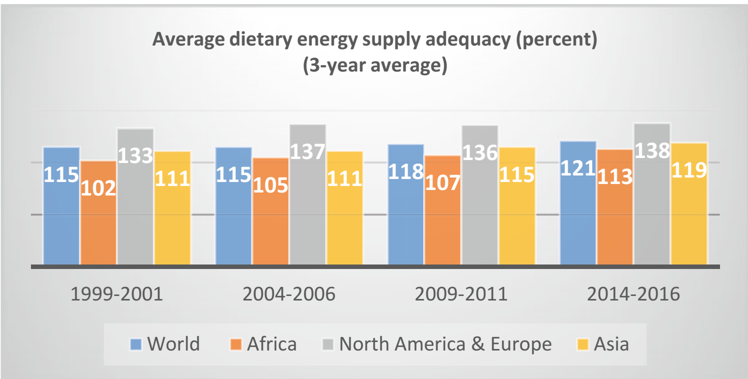

Fig. 1.1 Average dietary energy supply adequacy in selected regions and world (source: FAOSTAT 2020)

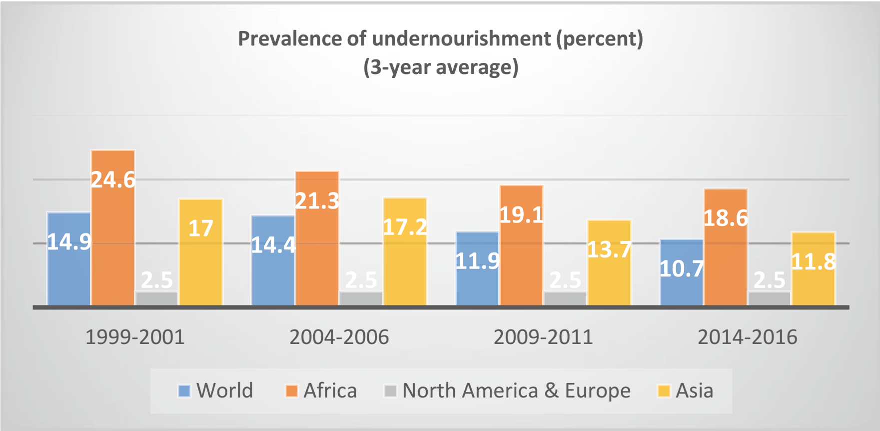

Fig. 1.2 Prevalence of undernourishment in selected regions and world (source: FAOSTAT 2020)

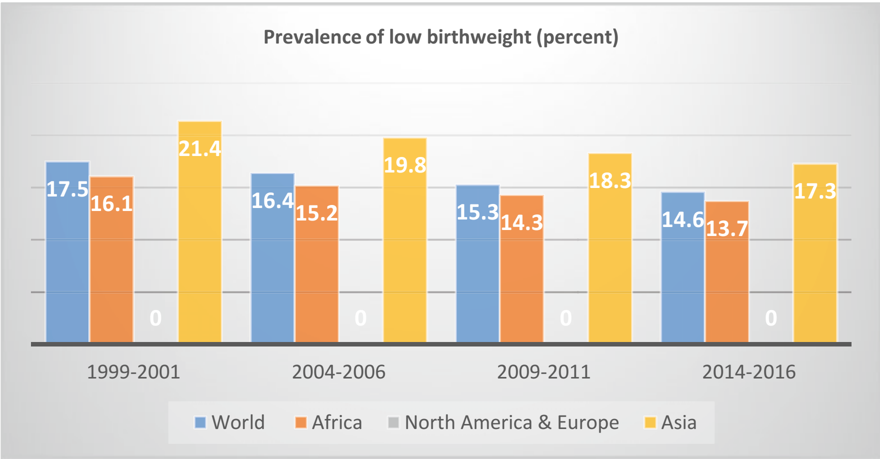

Fig. 1.3 Prevalence of low birthweight in selected regions and world (source: FAOSTAT 2020)

means that one in every nine people in the world suffers from hunger (FAOSTAT 2020).

Thus concerns of food and nutritional security need to be addressed further through nutritious and sufficient food access to populations including pregnant women and children. To overcome this situation those fruits and vegetables should be popularized, which are available throughout the regions in all the seasons and are in reach of all income groups, especially economically weaker sections.

1.2 Global Potato Production and Consumption Scenario

The potato crop is an ideal crop for areas with limited land and large manpower availability, the situation which is existing in the developing world. Besides, potato crop is known to produce more food per unit area and time compared to major cereals like wheat, rice and maize. Being a labour intensive crop, for its cultivation and post-harvest operations, lot of manpower is required, which generates employment and source of income for economically weaker sections, particularly in developing countries. FAO therefore, has emphasized that potential of potato crop should be fully exploited in the African and Asian regions.

The annual potato production during the triennium ending (TE) 2013 was estimated to be around 370 million tonnes and India and China emerged as major producers of potatoes in this period, leaving behind the Russian Federation (43.1, 88.2 and 30.8 million tonne, respectively, during TE 2013). Till the last millennium, the major producers and consumers were from developed world, whereas the scenario has changed over the period. A comparison of growth rate in potato production during TE ending in 2003 and 2013 depicts that Africa has registered the highest growth (97%) followed by Asia (Fig. 1.4) (CPRI 2015). At present about 1/3rd of the global potato production is coming from emerging Asian economies, viz. China and India, with the production levels of 90 mmt in China and 48 mmt in India registered during 2018 (FAOSTAT 2020). Similarly, in most of the developing countries, potato production as well as per capita availability are also accelerating creating expectations that this trend will continue in near future also (Figs. 1.5 and 1.6).

Potato consumption has shown declining trend in the developed world during last decade in Americas, Europe, Oceania and Russian Federation showing −8.8, −9.4,

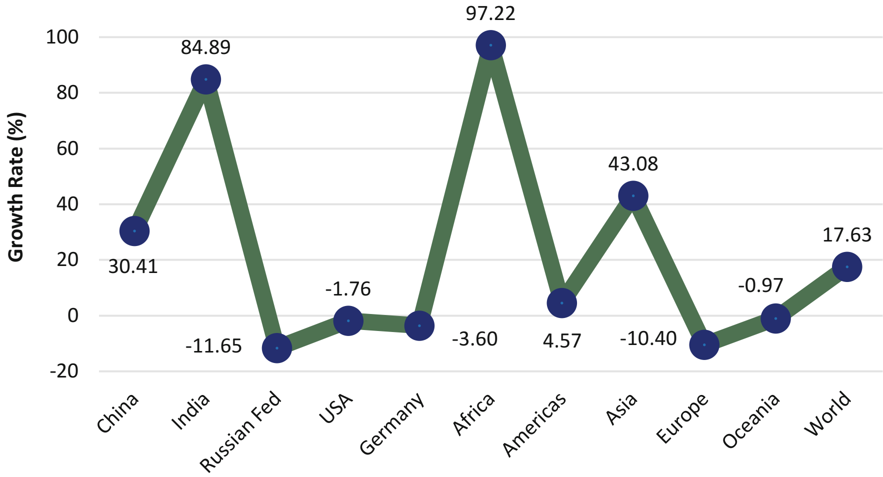

Fig. 1.4 Potato production growth (%) over major potato producing nations and continents during TE 2003 and TE 2013 (Source: CPRI 2015)

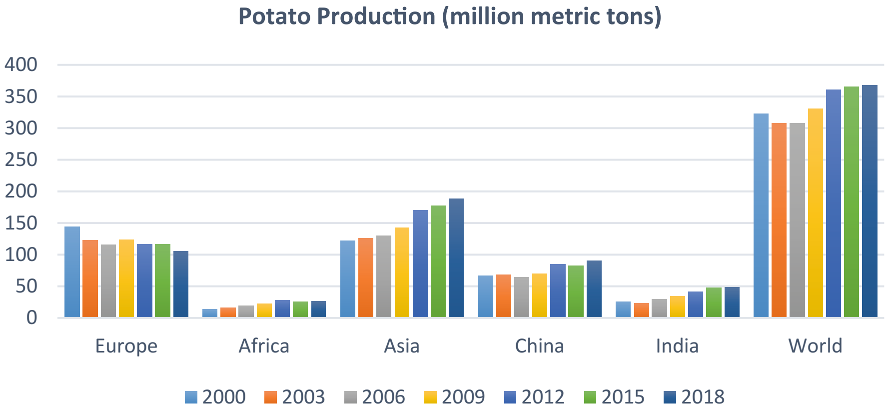

Fig. 1.5 Potato production in different parts of the world during 2000–2018 (FAOSTAT 2020)

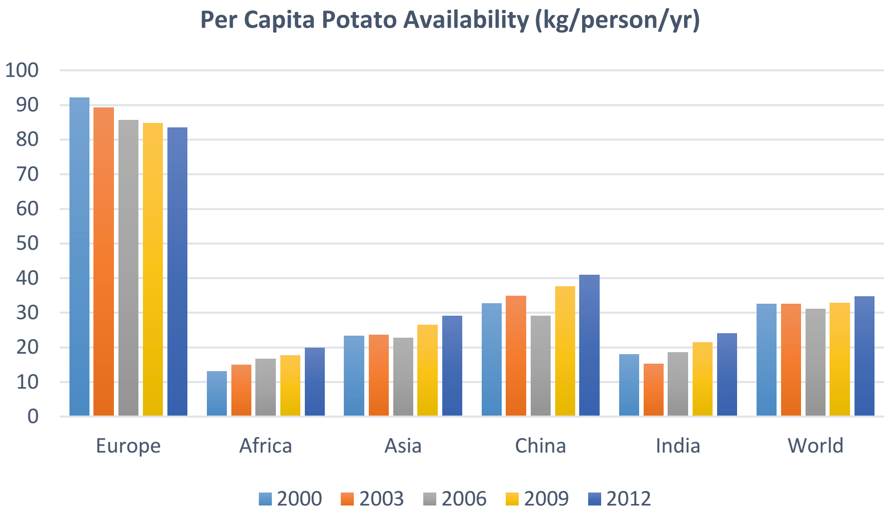

Fig. 1.6 Per capita potato availability in different parts of the world during 2000–2012 (FAOSTAT 2020)

−8.3 and −2.4% growth, respectively, whereas the developing world has shown increasing trend (Africa, Asia, India and China with 40.6, 25.6, 37.1 and 28.8% growth, respectively (FAOSTAT 2015, CPRI 2015). Thus, the growth in per capita as well as total potato consumption during this period had been the highest in Asia, though there could be issues related to productivity in several countries of Asia.

Due to the high productivity per unit area, potato is preferred in countries with high population density. The other favouring attributes include its flexibility of fitting into several prevailing cropping systems and stable yields over different environments compared to other crops. Simultaneously, the consumption of potatoes in these regions is also increasing as a result of increased industrialization and women employment creating enhanced demand for processed and ready-to-eat convenience food. There is also a perceptible shift in food preference from cereals to vegetables and fruits in such areas.

1.3 Nutritional Significance of Potatoes

Potato (*Solanum tuberosum*) is one such candidate that can solve the problem of food security as well as malnutrition. Potato was accepted as a primary vegetable supplement because of its mild flavour and its utilization in combination with other foods. Nutritional value of potato was known since long, specially its high content of ascorbic acid to prevent scurvy. One of the prominent publications of the Food and Agriculture Organization (FAO 2008) has emphatically considered and recommended potato as a potential crop for the poorest of the poor, to ensure global food, nutritional and income security in future.

Potato is a good option for food and is capable of producing nutritious food more quickly on lesser land compared to any other major food crops. Attributing to high protein-calorie ratio (17 g protein: 1000 kcal) and short life cycle, potatoes produce more edible energy, protein and dry matter yield on per unit basis in comparison to major food crops. Farmers can harvest up to 80% of biomass as edible, nutritious food in case of potato, whereas in case of cereals only up to 50% can be harvested as grains. Growth of potato in terms of production and productivity has remained higher in comparison to maize, rice and wheat. Serious food security problem will appear in future due to stagnation of crop yields, exhausting soils and increasing population in the developing world. In such a scenario, potato provides a ray of hope due to its highest per hectare, per day production of edible dry matter, calorie and vital nutrients.

Potato is known to be a highly productive vegetable, which may provide food and nutrition to bigger population. Due to its versatility in way of cooking, viz. boiling, baking, deep frying, etc. potato became popular over the period of time and is being consumed by one and all. Potato is popularly known as the 'Vegetable King'. It may be consumed in the form of snacks (chips, fries and dehydrated products) by the rich, whereas most of the low income households consume potato as primary or secondary source of food as well as nutrition. The nutritional value of potato is well acclaimed and is known as a versatile, carbohydrate rich and low-fat food. Potatoes at fresh harvest may contain approximately 80% water and 20% dry matter, out of this dry matter approximately 60–80% is constituted in the form of starch. Its content of dry matter, edible energy and edible protein makes it a good choice for nutrients availability. On dry weight basis, the protein content of potatoes is comparable to cereals and higher when compared to other roots and tubers. Potato is well known to consumers as a source of energy, but its significance of supplying vital nutrients is not well recognized. Potato is an excellent source of complex carbohydrates, dietary fibres and vitamin C. It also contains a variety of health-promoting compounds, such as phytonutrients, that have antioxidative activity. Some of the health-promoting compounds present in potatoes include carotenoids, flavonoids, and caffeic acid. Besides, unique tuber storage proteins like patatin known to exhibit activity against free radicals is also present in it. Potato is also a substantial source of ascorbic acid, thiamine, niacin, pantothenic acid and riboflavin. Due to the nutritional value of potato, it is highly desirable in human diet. The nutritive value of a potato containing food depends on the other components served with it and on the method of preparation. As it is, potato does not contain much of fat and the feeling of satiety it gives, is helpful for the people aiming weight reduction. However, the caloric value of the potato containing dish may increase if it is prepared and served with high fat ingredients. The starch of raw potato is not easily digestible, hence, potatoes have to be cooked before consumption by boiling (with or without the skin), baking or frying and depending on the cooking method, the potato composition get changed in different ways.

Raw potato (on dry weight basis) provides about 80 kcal energy, whereas a boiled potato provides about 69 kcal energy per 100 g of weight (Singh et al. 2020). Due to its low energy density, potatoes are good for weight conscious people, if they eat potatoes without adding fat in it. The energy value of potatoes is low compared to rice, wheat, maize and sorghum. The energy value is even lower than other tuber and root crops as well as food products from animal origin. Potatoes are an excellent source of complex carbohydrates. These carbohydrates take longer time for break down into glucose and result in energy that lasts longer. Complex carbohydrates are longer chains of sugars, such as starches and fibre. In potatoes, the major carbohydrate is in form of starch, whereas main sugars include sucrose, fructose and glucose. Carbohydrates are the body’s primary source of fuel for energy. The energy produced through potato gets stored as glycogen in muscle and liver and functions as a readily available energy during prolonged, strenuous exercise. Sugars are the most basic carbohydrates, the building blocks of complex carbohydrates. Starch furnishes most of the energy supplied by the potato. Digestibility of starch influences the energy value of the potato and hence also the bulk of potato which must be eaten to supply a given amount of energy.

Potato is a rich source of dietary fibre. Cellulose, pectin and pectin associated substances are higher in potatoes compared to cereal bran. Dietary fibre content in raw potato tuber ranges from 1 to 2 g/100 g fresh weight. Unpeeled potatoes contain more dietary fibres than peeled potatoes. The dietary fibre from potato tuber comes mainly from its cell walls that constitute about 1.2% of the fresh weight of the tubers. To increase the dietary fibre intake, potatoes must be consumed along with peel. More than half of the dietary fibre in potato is in the form of pectic substances which improves the quality of potato dietary fibre and thus helps in lowering cholesterol levels. One medium potato may supply 8% of the daily value of fibre (about 2 g). Dietary fibre is a complex carbohydrate and it cannot be digested and absorbed in the bloodstream, though it is known to have several health benefits like improving blood lipid levels, regulating blood glucose and increasing satiety. The main constituents of dietary fibre include non-starch polysaccharides (NSP), lignin, resistant starch and non-digestible oligosaccharides. Potatoes also contain resistant starch which are ‘starch and starch degradation products that escape digestion in the small intestine of healthy individuals'. Resistant starch acts in similar fashion as fibres and is found naturally in foods such as legumes, bananas, potatoes and some unprocessed whole grains. In Indian potatoes resistant starch content is approximately 1.5–2% in cooked and cooled tubers (Raigond et al. 2014). The natural resistant starch is generally insoluble and gets fermented in the large intestine and acts as a prebiotic fibre. However, some other types of resistant starch are known, which may or may not be soluble and also might not have prebiotic properties. The resistant starch concentration of potatoes gets affected by cooking and processing. Generally, cooking and cooling result in about two-fold increase in its concentration. Resistant starch is also known to be present in significant amounts in processed potatoes like flakes. It has been categorized as the third type of dietary fibre since it shows the attributes of both soluble and insoluble fibres.

Potato has been known as a very good source of high quality protein. Average protein content of potato is 2% on fresh weight basis and about 10% on dry weight basis (Sato et al. 2017). Potato protein content is lower than wheat, rice, corn, sorghum and beans but is higher than other major root and tuber crops like sweet potato, yam and cassava. The total nitrogen in potatoes is contained in the form of soluble protein, insoluble protein and soluble non-protein nitrogen. The insoluble protein fraction is mainly present in the peel. Soluble potato protein contains substantial levels of the essential amino acids. Free amino acids present in potatoes are totally available for absorption. The protein exhibits adequate ratio of essential amino acids to total amino acids and can meet the needs of infants and small children. However, the digestibility of potato protein is relatively low in infants. Potato protein has a very high biological value since all the essential amino acids are present in it are in balanced proportion. The biological value of proteins in potato is high compared to major cereals and sometimes even higher than that of animal origin like milk and beef. The high lysine content of potato is helpful in supplementing diets having limited lysine composition. Potato thus, has advantage over cereals in for vegans due to its ability to provide high quality protein. Diet which can fulfil only the energy requirement of body cannot support growth of children, if its protein content is below the recommended requirement. However, if a diet provides inadequate energy, its protein is metabolized as a source of energy rather than being used for growth. Therefore, diet should be well balanced in terms of energy and protein. Therefore, potato is a superb food which has correct balance between net protein calories and total calories adequate for all age groups.

There is a common misconception that eating potato may cause obesity due to its high fat content which is not at all a true statement, since potatoes contain very little quantity of fat. The average fat content of potato is 0.1% on fresh weight basis which is too low to have any negative nutritional significance (Ramadan 2016). Fat content in potato is lower than major cereals like rice, wheat, maize and sorghum. The little fat present in potato contributes towards potato palatability. Major proportion (i.e. nearly 60–80%) of potato fat consists of unsaturated fatty acids and linoleic acid is the predominant one and these unsaturated fatty acids, in fact increase the nutritive value of the fat. Due to its low energy density, potato is also good for weight conscious people if they consume potatoes without adding fat. Of course, if fat is added to the fried or processed potato products, it becomes rich in calorie. Especially excessive consumption of processed potato products such as chips and French fries containing up to 40% fat may not be so healthy.

Potato is also a good source of important minerals and trace elements. Hundred grams of potato contains approximately 40–65 mg of phosphorus and due to relatively small percentage of phytic acid present in potato, the assimilation of phosphorous is high. The lower phytic acid content of potatoes enhances phosphorous bioavailability to human body and also helps in increased bioavailability of calcium, iron and zinc. The potassium content of potato is also relatively high, i.e. 247–455 mg/100 g fresh weight. Since potassium content in potatoes is high, it is generally not included in the diet of patients having renal issues. The sodium content of potato is very low limited to about 11 mg/100 g fresh weight. Potatoes are a good source of iron and their iron content is comparable to most of the other vegetables. In fact, about 6 and 12% of daily iron requirement for children and adult can be met from 100g of cooked potato (O'Neill 2005). Moreover, due to high ascorbic acid content of potato, bioavailability of non-haem form of iron from potato is increased. Potatoes mixed with other food are also beneficial as it increases the bioavailability of iron from other foods also due to its high ascorbic acid content. Moreover iron availability from potato is higher compared to other foods such as kidney beans, wheat flour and bread, reason being the high proportion of iron from potato is soluble. Potatoes provide a good source of magnesium, which is up to 22 mg/100 g fresh weight. Potato can be consumed with foods low in magnesium such as milk. Magnesium content of milk is one-fifth to one-tenth of potato. Hence potato is superior to milk in terms of magnesium, but consumed together they form best combination as milk is rich in calcium and potato provides magnesium. Zinc is an important trace element though, its concentration in potato is less, but its availability is high due to low phytic acid content. Potatoes can also supply at least part of daily requirements of other trace elements like manganese, copper, molybdenum and chromium. Traces of boron, bromine, iodine, aluminium, cobalt and selenium are also present in potato. A small potato can deliver 10% daily value of folate, manganese, magnesium and phosphorus. Therefore, potato being in reach of poorest of the poor can play a vital role in eradication of 'Hidden Hunger' which is also known as micronutrient malnutrition.

Potato contains 19–58 mg of ascorbic acid per 100 g tuber. Potatoes have high quantities of vitamin C on average than other vegetables like carrots, onion and beet root. When consumed in sufficient quantities, potatoes itself can meet all the vitamin C requirements of an individual. Potato may act as an important source of several vitamins like thiamine, niacin and pyridoxine and its derivatives (vitamin B6 group). Potatoes also contain small amounts of pantothenic acid (vitamin B5), riboflavin and folic acid. These B-vitamins are essentially known for general health and growth benefits. However it is recommended that potatoes should not be washed after peeling to prevent loss of vitamins. A small potato can deliver more than 20% daily value of vitamin C and vitamin B6 (Singh et al. 2020).

Along with vitamins and minerals, potatoes contain a number of small molecules, many of which are beneficial phytonutrients such as phenols, flavonoids,