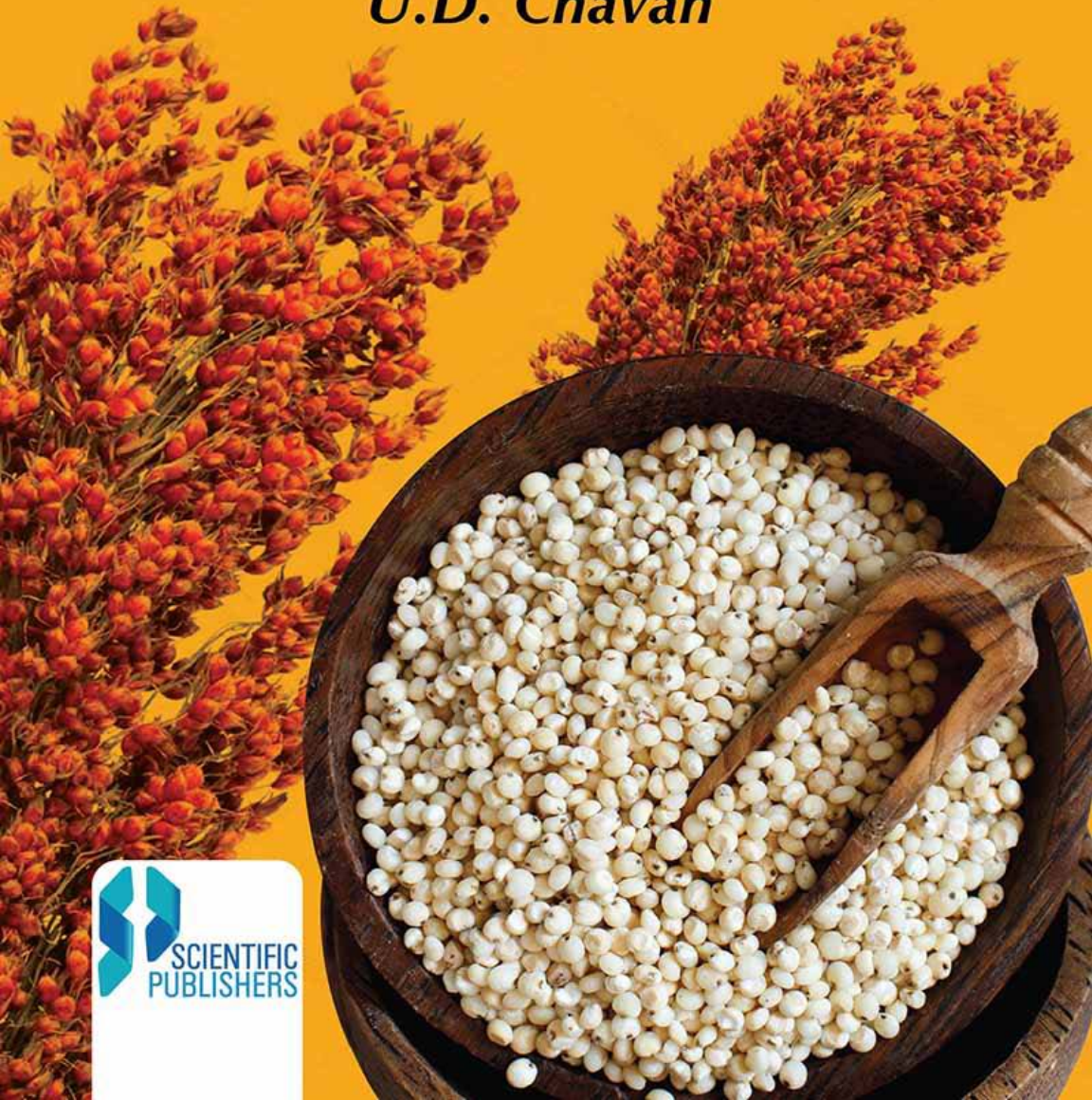
Sorghum

Medicinal Food

(Medicinal and Industrial Perspective)

U.D. Chavan



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The Author

Dr. U.D. Chavan obtained his B. Sc. and M. Sc. (Agri. in Biochemistry) degrees from Mahatma Phule Krishi Vidyapeeth Rahuri in 1985 and 1987 respectively. He received his Ph.D. degree in Food Science from Memorial University of Newfoundland St. John's Canada in 1999. He has done International training on "Global Nutrition 2002" at Uppsala University Uppsala, Sweden in 2002. He also attended follow-up International workshop on "Global Nutrition 2002" at Hanoi, Vietnam in 2002. Dr. Chavan visited Denmark, Finland, Ireland, France, Switzerland, Poland, Spain, Vietnam, Thailand, England, and U.S.A. under "Global Nutrition 2002" Programme sponsored by Swedish International Development Agency (SIDA). During this programme he worked on human nutritional diet and disorders as well as on genetically modified organisms (GMO).

Dr. Chavan worked as Senior Research Assistant in the Department of Biochemistry and Food Science and Technology at Mahatma Phule Krishi Vidyapeeth Rahuri from 1988 to 2000. During his Ph. D., he worked as Technician/Research Associate at Atlantic Cool Climate Crop Research Center and Agriculture and Agri-Food Canada. He received D.Sc. degree in 2006 from USA. He has guided 25 students for M.Sc. (Agri.) in Biochemistry and Food Science and Technology. From 2000 to 2004 he worked as Assistant Professor of Biochemistry at Mahatma Phule Krishi Vidyapeeth Rahuri.

Dr. Chavan received Korgavkar Trust Fellowship, under-graduate and post-graduate merit scholarship as well as Senior Research Fellowship from ICAR, New Delhi and United States Department of Agriculture U.S.A. He received University Graduate Fellowship from Memorial University of Newfoundland St. John's Canada for his Ph. D. programme. Dr. Chavan also received international Scholar Award and Excellentiam Award for his Ph.D. research work from Memorial University of Newfoundland St. John's Canada. He has received a "Certificate of Appreciation" from the U.S. Department of Agriculture in 1992 for his work on processing of groundnut under the guidance of Dr. S.S. Kadam (Principle Investigator). He has written 135 research papers and 140 popular articles. He has authored 19 books in Marathi, 23 books in English and eight book chapters in English. Dr. Chavan has visited 23 countries in the world for research and teaching programmes. He has been awarded **"Literary Award"** for his best book on **"Growth Regular"** on agriculture during **1997** by Government of Maharashtra. Dr. Chavan was selected as a best group leader and best presentation for "Global Nutrition 2002" by SIDA. He has been awarded "Life Time Achievement Award 2004" for his outstanding contribution in post-harvest technology of fruits and vegetables and allied fields by United Writers' Association of India. He has been elected as a Fellow of United Writers' Association of India in 2004. Dr. Chavan received pride of nation and Maharashtra Gunigan Ratna Award for 2006. He also received Jewels of India Award for 2006 for his contribution in the field of Food Science and Technology. He has been awarded **"Literary Awards"** for his best book on **"Sorghum Grain Processing"** on agriculture during **2009-2010** and **"Pulses cultivation to processing and value addition"** for **2012** by Government of Maharashtra. He is recipient of "Krishi Goorav Award-2011" from Bhartiya Krishak Samaj, Maharashtra State, Nasik. He also contributed in the development of crop varieties in wheat NIAW-917 and in Sorghum Phule Anuradha (RSV 423), Phule Chitra (RSV 1546), Phule Suchitra (RSV 1098), Phule Vasudha (RSV 423), Phule Revati (RSV 1006), SPV-1626, Phule Panchami (RSPOV-3) for Sorghum pops, Phule Godhan (SPV-2057) for forage single cut, CSH-50 (Sweet Sorghum), Phule Madhur (RSSGV – 46) for sorghum *hurda* and Phule Rohini (RPASV-3) for sorghum *papad*. Now he is working as a Head of the Department of Food Science and Technology, as well as a Senior Cereal Food Technologist in Sorghum Improvement Project and Foreign Student Advisor at Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist, Ahmednagar, Maharashtra, India.

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Content

Foreword

The relationship between diet, moderate physical activity and health is of much current interest. Although initial evidence for this relationship was mainly epidemiological in nature, recent advances and developments in the area of nutraceuticals and functional foods have led to substantiation of claims by preclinical and clinical studies. Furthermore, availability of sophisticated analytical tools has led to the identification and appreciation of non-nutrient bioactives in the diet. Another motivating factor has been mounting health care costs that have emphasized a need for a preventive rather than a treatment approach by consumers, health professionals, researchers and perhaps some government departments in certain countries. The emerging findings in nutrigenomics and proteomics and the advent of nanotechnology for better delivery of bioactives have opened the way for individualized dietary regimes in the hopefully not too distant future. Over the past decade or two there has been a surge in the publication of research findings and developments in the field, although often in a non-targeted and fragmentary manner. Therefore, to fill the existing gap, the launch of a dedicated book for **"Sorghum Medicinal Food** (Medicinal and Industrial Perspectives)**"** was deemed necessary. This idea was first come in the mind of author and Astral Publication committed to publish this type of book. In this book medicinal properties of sorghum and value added products from sorghum are given in details. I think author has chosen the wright subject of the book and I hope this book will serve the purpose of students, teachers, readers, consumers and professional industrial processors.

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Preface

Sorghum contains various phytochemicals (including phenolic compounds, plant sterols and policosanols) that are secondary plant metabolites or integral cellular components. Phenols help in the natural defense of plants against pests and diseases, while the plant sterols and policosanols are mostly components of wax and plant oils. The phytochemicals have gained increased interest due to their antioxidant activity, cholesterol lowering properties and other potential health benefits. The phenols in sorghums fall under two major categories; phenolic acids and flavonoids. The phenolic acids are benzoic or cinnamic acid derivatives, whereas the flavonoids include tannins and anthocyanins as the most important constituents isolated from sorghum to date. Sorghum phytosterols are similar in composition to those from corn and contain mostly free sterols or stanols and their fatty acid ferulate esters. The sterols and stanols are structurally similar, except for the presence of a double bond at position 5 in sterols, which is lacking in stanols. The policosanols (fatty alcohols) exist mostly as free or esterified forms with C_{24}–C_{34} atoms, and the general formula CH_3–$(CH_2)_n$ – CH_2OH. In sorghum-free forms of the C_{28} (octacosanol) and C_{30} (triacontanol) are the most abundant.

Despite the high levels and diversity of phytochemicals in sorghum, research on this crop as a source of valuable health promoting compounds lags behind other commodities (e.g., fruits and vegetables). As a result, utilization of sorghum fractions in foods to improve nutrition is very limited. Sorghum has a big potential, given its agronomic properties, as well as the emerging evidence on the biological effects of the phytochemicals present in the grain. The purpose of this book is to demonstrate that sorghums with special characteristics exist that have potential as significant sources of condensed tannins, anthocyanins and other phytochemicals with properties that complement the phytochemicals present in fruits and vegetables.

U.D. Chavan

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Author is thankful to the Hon. Dr. S. S. Kadam, Hon. Ex. Vice-Chancellor, Marathwada Agricultural University, Parbhani and Ex. Head Department of Food Science and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri for his critical and fruitful suggestions while the preparation of **"Sorghum Medicinal Food** (Medicinal and Industrial Perspectives)**"** book. I am thankful to Dr. Fereidoon, Shahidi, Dr. J. K. Chavan, Dr. Amarowicz Ryszard, Dr. J. V. Patil, Dr. V. D. Pawar, Dr. U. Y. Bhoite, Dr. K. D. Chavan, Dr. C. A. Nimbalkar, Mr. Ajay Jadhav, Mr. Kashinath Bagale, Mr. Suresh Shedage for helping during this manuscript preparation, as well as those scientists who worked on phenolic antioxidants and health benefits identification, utilization and usefulness for human beings and their contribution is acknowledged in this book as well their sources are cited in the reference section. Authors are also thankful to all scientists and friends those helped directly or indirectly while preparation of this manuscript. We would like to express over profound thanks to our family members for their constant support, patience and devotion, which inspired me to complete this manuscript.

U.D. Chavan

Chapter – 1

Introduction

Sorghum (*Sorghum bicolour* L. Moench) is a genus of numerous species of grasses, one of which is raised for grain and many of which are used as fodder plants either cultivated or as part of pasture. The plants are cultivated in warmer climates worldwide. Species are native to tropical and subtropical regions of all continents in addition to the southwest Pacific and Australasia. Sorghum is in the subfamily Panicodeae and the tribe Andropogoneae (the tribe of big bluestem and sugar cane). Sorghum is divided in 29 species and two hybrids as follows:

SORGHUM SPECIES

The known species of the sorghum are listed here for information to the students, teachers and researchers for future development in the field of sorghum research. *Sorghum almum; Sorghum amplum; Sorghum angustum; Sorghum arundinaceum; Sorghum bicolour* cultivated sorghum, often individually called sorghum. Also known as durra, jowari, or milo; *Sorghum bicolour subsp. drummondii Sudan grass; Sorghum brachypodum; Sorghum bulbosum; Sorghum burmahicum; Sorghum ecarinatum; Sorghum exstans; Sorghum grande; Sorghum halepense* Johnson grass; *Sorghum interjectum; Sorghum intrans; Sorghum laxiflorum; Sorghum leiocladum; Sorghum macrospermum; Sorghum matarankense; Sorghum nitidum; Sorghum plumosum; Sorghum propinquum; Sorghum purpureosericeum; Sorghum stipoideum; Sorghum timorense; Sorghum trichocladum; Sorghum versicolour; Sorghum verticiliflorum; Sorghum vulgare* var. *technicum* broomcorn and two hybrids *Sorghum x almum*; *Sorghum x drummondii*.

One species, *Sorghum bicolor*, is an important world crop, used for food (as grain and in sorghum syrup or sorghum molasses), fodder, the production of alcoholic beverages and biofuels. Most varieties are drought and heat-tolerant, and are especially important in arid regions, where the grain is one of the staples for poor and rural people. These varieties form important components of pastures in many tropical regions. *Sorghum bicolor* is an important food crop in Africa, Central America and South Asia and is the fifth most important Cereal crop grown in the world after rice, wheat, maize and barley.

Sorghum is one of the major cereal crops among the all millets grown mostly in dryland. It is grown as rainfed crop in both season *Kharif* (mansoon) and *Rabi* (winter). It is mainly grown in the Deccan plateau, Central and Western India apart from a few patches in northern India. Almost entire grain produce is used for human consumption in India. It is nutritionally superior to other fine cereals such as rice and wheat and hence it is known as nutritious cereal. Nutritionally sorghum grain contains 4.4 to 21.1% protein, 2.1 to 7.6% fat, 1.0 to 3.4% crude fiber, 57.0 to 80.6% total carbohydrates, 55.6 to 75.2% starch and 1.3 to 3.5% total minerals (ash). Sorghum also provides 350 Kcal energy, calcium, phosphorus, potassium, carotene and thiamin as well as antioxidants through phenolics and various types of tannins. It is mainly consumed as *Bhkari* (*roti*) i.e. un-leavened pancake in various states of India. Apart from the traditional products like *bhakari, bhatwadi, papad, popped grains, kurdai, high fibre cookies, biscuits, flakes, thalipeeth, upama, rawa idali, dosa, uttappa, chiwada, chakali, papadi, ambil, shankarpale, cookies and cakes* are also prepared from sorghum and consumed as snack food items. Sorghum grains are not only good source of nutrients but it also contains special constituents such as phyto-chemicals, dietary fbire as well as resistant starch, which are more essential to the human nutrition. However, the grain sorghum consumption has remained restricted to the weaker sections of the society due to poor nutritional quality of grain and inferior quality of the products such as Bhakari as well as very low price of this food item as compared to the other cereal grains such as wheat, rice and other millets.

Sorghum is of African origin. A large variety of wild and cultivated sorghum are grown in the tropics and subtropics of the world. In India, sorghum constitutes an important article of food, after rice and wheat. The sorghum grain is small and rounded, varying in colour from off-white to white to varying shades of red, yellow or brown. The grain size varies, the weight ranging from 7.0 to 61 g/1000 grains, with most sorghums weighing 20 – 30 g/1000 grains. The chemical composition of grain sorghum is similar to that of maize. Generally, sorghum has more protein than maize, a lower fat content and about the same amount and proportions of carbohydrate components. The proximate analysis of Indian sorghum grain indicates moisture, 11.9; protein 10.4; fat 1.9; fiber 1.6; carbohydrates 72.6 and minerals 1.6; minerals present in the grain are calcium, magnesium, potassium and iron.

In comparison with maize, sorghum grain contains approximately the same quantities of riboflavin and pyridoxine but more pantothenic acid, nicotinic acid and biotin. Nicotinic acid occurs in the grain in available form.

Starch is the major carbohydrate of the grain. The other carbohydrates present are simple sugars, cellulose and hemicelluloses. The amylose content of starch varies from 2 1 to 28%. Starch from waxy varieties contains little amylose. Both waxy and regular starches contain free sugars upto 1.2%. Sucrose being the major constituent (0.85%) followed by glucose (0.09%), fructose (0.09%), maltose and stachyose. Sorghum grain contains no detectable amount of