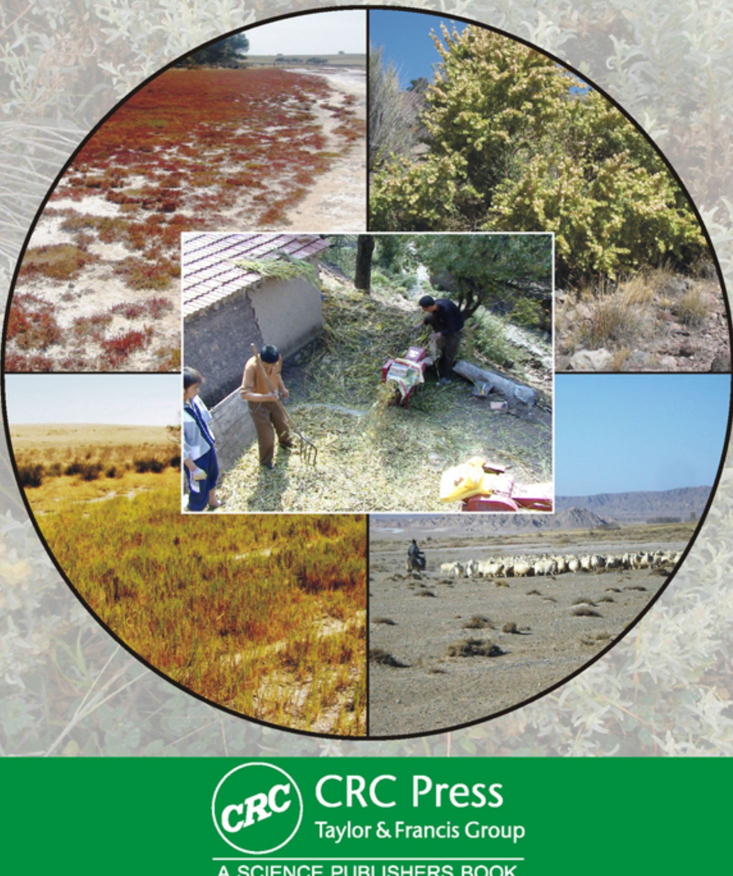
Halophytic and Salt-Tolerant Feedstuffs

Impacts on Nutrition, Physiology and Reproduction of Livestock

Hassan M. El Shaer and Victor R. Squires (*Editors*)



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Preface

Use of halophytes as animal feedstuffs attracted attention of scientists toward the latter half of the twentieth century with the appearance of scientific papers[1] on effect of brackish drinking water and salty feed on animal health and meat quality/quantity and the problems encountered in such studies were identified. Subsequently, scattered reports appeared in the literature where scientists from Australia, India, Pakistan, Middle East, Africa and North/South America working in the relevant fields have attempted replacing the regular fodder with one or another halophyte or salt tolerant feedstuff.

Later, a series of monographs and edited multi-author books* on aspects of the physiology of salt tolerant plants animals were published. Attention was also focused on the use of salt tolerant plants that included obligate halophytes, as candidate species for rehabilitation of saline lands, including abandoned irrigation areas. The role of biomass produced on such rehabilitated lands and new ways to use such biomass, especially in mixed rations involving more conventional fodders, was also investigated. As the loss of arable land to secondary salinity became more widespread and as the agronomy of salt tolerant food crops was advanced attention turned to utilizing the crop by-products, including oil seed cakes and meals. Sea water irrigation of halophytes gained traction as the search for commercially viable biosaline systems were advanced. This development generated a larger quantity of potentially usable feedstuffs both as biomass and as by-product such as seed cake.

Finding suitable forage/fodder (and even grain crops) which does not encroach upon the land under conventional crops may be useful for cattle raising and meeting the requirement of meat, poultry and dairy products is a challenge and specialized research centers were established, principally in the Gulf region, the WANA region, Pakistan, Central Asia and USA (Arizona) and Australia. Concurrently there was interest in using halophytes for remediation of damaged lands, including mine sites. The potential of salt tolerant plants, including extreme halophytes, for carbon sequestration also received attention. Some of the biomass derived from C sequestration plantations began to enter the supply chain for feedlots where guaranteed supplies of high quantities of suitable feedstuffs are required. In addition to salt tolerant and halophytic plants grown under intensive cultivation there are extensive areas of naturally-occurring shrublands, woodlands and grasslands that are used as fodder reserves or protein supplements, either grazed/bowsed by livestock or in cut-and-carry systems.

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[1] See a list of these in the various reference lists at the end of each chapter.

* See footnote 1.

The volume of data generated and the interest in filling the 'feed gap' in many animal production systems, especially in arid and semi arid regions, has provided impetus to convene International and, regional and national symposia and spawned special issues of journals (e.g., *Small Ruminant Nutrition*) and various conference proceedings. The plethora of information generated by nutritionists, animal physiologists, veterinarians, agronomists and livestock specialists is scattered throughout reports, journal articles and some specialist monographs but lacks integration and synthesis into a coordinated body of knowledge. In this book we attempt a synthesis that considers the role and potential of salt tolerant and halophytic feedstuffs and their impacts on nutrition, physiology and reproduction of livestock, including ruminants and non ruminants such and poultry and rabbits.

The breadth and complexity of the subject matter presented here is vast. To make it easier for the reader the volume of 23 chapters is divided into 5 parts.

Part 1 of 5 chapters presents a synoptic overview of the diversity (taxonomy and life form) extent and geographic distribution of salt tolerant and halophytic feed sources and attempts to quantify the potential tonnage of such materials. Special attention is given to the vast Mediterranean and North African/Gulf region[2] where aridity and salinity are taking their toll on human and livestock populations. Intake and nutritive value of some salt-tolerant fodder grasses and shrubs for livestock are illustrated with selected examples from across the globe. Specific experience in the Gulf region with halophytic feedstuffs in mixed rations for sheep and goats receives attention here.

Part 2 of 4 chapters focuses on nutritional aspects and assesses the peculiar situation where many halophytic and salt tolerant feedstuffs have a high level of anti-nutritional compounds that inhibit digestibility and feed value. Others contain toxins that create health hazards or otherwise restrict their usefulness in livestock rations. Detailed consideration is given to what is known about such phyto-toxins and we also explore the pitfalls involved in evaluating the true value of such feedstuffs. Special attention is paid to livestock productivity (weight gain, egg production, etc.).

Part 3 of 4 chapters reviews experience on using halophytic and salt tolerant feedstuffs from around the world. Feeding trials have been conducted on a wide range of feedstuffs (trees, shrubs, grasses and forbs—even sea weed) when they were fed to small ruminants (sheep and goats), cattle, camels in various forms (fresh, dry or ensiled).

Part 4 of 6 chapters reviews and synthesizes knowledge on the physiological impacts of heavy salt and toxin loads on digestion, reproduction and health, with special attention to rumen function. Water is both an important nutrient that is vital to body functioning (excretion, temperature regulation, food and energy transport, etc.) and obviously is affected by mineral ash intake that may increase when livestock eat feedstuffs high in sodium (Na) and potassium (K) and have access to water that may contain other electrolytes and minerals such as magnesium (Mg), calcium (Ca), etc. The role of water as a regulator of feed intake, and rumen function is explored in both ruminants and non ruminants. Reproductive physiology, including impact of high salt loads on

[2] Variously called WANA (West and North Africa) or MENA (Mediterranean North Africa).

fertility of both, males and females, milk production and skin, hair and wool production in ruminants. Sheep, goats and camels are the main livestock considered here.

Part 5 of 4 chapters is about non-ruminants and considers the special dietary requirements of poultry and rabbits as well as the differences between ruminant and non-ruminant fermentation processes. By comparison some aspects of the special adaptation by a desert dwelling rodent that is almost wholly dependent on a halophyte for its survival is highlighted here. A special case study is presented on the processing equipment used in making salt tolerant and halophytic feedstuffs more acceptable to livestock and which also retain feed value and reduce wastage. We conclude with a brief section on uniting perspectives and some suggestions about how to cope with the remaining problems and speculate about the prospects for overcoming the challenges.

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The contribution of Dr. Salah Attia-Ismail of the Desert Research Center in Cairo is especially appreciated. He has contributed as author, co-author, reviewer and coordinator.

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List of Acronyms, Abbreviations and Equivalents

ADF	Acid Detergent Fibre
ADIN	Acid Detergent Insoluble Nitrogen
ADL	Acid Detergent Lignin
ADMR	Average Daily Metabolic Rate
AFRC	Agricultural and Food Research Council (UK)
AIA	Acid-insoluble ash
AOAD	Arab Organization for Agriculture Development
BW	Body Weight
CBG	Crushed Barley Grains
CDS	Crushed Date Seeds
CPD	Crude Protein Digestibility
CSIRO	Commonwealth Scientific Industrial Research Organization (Australia)
DCP	Digestible Crude Protein
DMI	Dry Matter Intake
DOM	Digestible Organic Matter
DPLS	Digestible Protein Leaving the Stomach
DRC	Desert Research Center (Egypt)
dS/m	deci Siemens per metre—a measure of salinity
FAO	Food and Agriculture Organization of the UN
FWI	Feed Water Intake
GEF	Global Environment Facility
HSTF	Halophytes and Salt Tolerant Forages
ICARDA	International Center for Agriculture in Dry Areas
ICBA	International Center for Biosaline Agriculture
ICRAF	International Center for Research in Agroforestry
IFAD	International Fund for Agricultural Development
IVOMD	*In vitro* Organic Matter Digestibility
MCP	Microbial Crude Protein
MENA	Middle East and North Africa region
MER	Maintenance Energy Requirement
Mha	Millions of hectares
NDF	Neutral Detergent Fiber
NFE	Nitrogen-free Extract

NGO	Non Government Organizations
nM	nM = nanomolar = nannomoles per litre = 10^{-9} moles per litre
NIRS	Near Infrared Reflectance Spectroscopy
OM	Organic Matter
ppm	Parts per million
RDP	Rumen degradable protein
SCA	Standing Committee on Agriculture (Australia)
TAC	Total Antioxidant Capacity
TDN	Total Digestible Nutrients
UDP	Undegraded Dietary Protein
UN	United Nations
UNCBD	United Nations Convention on Biodiversity
UNCCD	United Nations Convention on Combating Desertification
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCC	UN Framework Agreement on Climate Change
USDA	United States Department of Agriculture
USAID	US agency for International Development
WANA	West Asia North Africa region
WB	World Bank
WHO	World Health Organization

Equivalents

100 hectares equals 1 km^2
1 feddan equals 0.42 hectares
Sabkha marine and continental salt flats equivalent to playa
1 dS/m = 1000 EC (or µS/cm) = approximately 640 mg/kg (or ppm)
Tibin = shredded barley straws