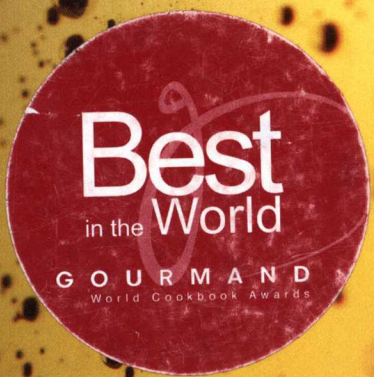
Alcohol and its Role in the Evolution of Human Society

Ian S Hornsey

Foreword by
Arthur Edward Guinness,
Earl of Iveagh



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Dedication

This book is dedicated to the memory of Dr. Denis Hide; tutor and friend.

Foreword

Hats off to Ian for producing such an informative and enlightening book.

Farming in the nutrient deficient soils of the Suffolk Brecks as I do, plant variety selection is of prime importance, as it is to farmers everywhere. In the aftermath of this dry early summer we face uncertainty as regards barley quality and yield. What is striking is that without the great advances in science and artificial selection, it would be doubtful whether we would have any crop to harvest.

This seminal book explains why we have selected the few plants that we have and why we have put so much effort into enhancing their sought-after qualities; matters of prime concern to humankind – our survival depends on our continued success.

These labours of ours can now for the first time be tracked to pre-history thanks to cutting-edge technology and this subject area will remain of utmost importance given our resource-scarce world as we ever increase the demands made upon it.

This book, Ian's fourth to be published by the Royal Society of Chemistry, unites archaeology and anthropology, plant breeding and industrial process, together with so many other disciplines besides. It is nothing short of revelatory and thoroughly up-to-date in our fast-moving world; this represents a Herculean effort on the part of the author.

Only through understanding the fundamentals of where we have come from can we achieve bountiful crops into the future and we should all raise a glass to that!

Arthur Edward Guinness, Earl of Iveagh

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Preface

It is almost impossible to imagine the world without ethanol as a component of many beverages, but one should not forget that the fact that we are able to enjoy such drinks as beer, malt whisky, wine and cider is primarily due to a single-celled fungus, *Saccharomyces cerevisiae*, the yeast. Many microbes are capable of fermenting sugars to obtain cellular energy, liberating, as they do, ethanol as a by-product. The extent of use of the pathway is, however, limited by the very toxicity of ethanol itself, which destabilizes cell membranes and interferes with other aspects of cellular metabolism. What deserves our eternal gratitude is the fact that, over the millennia, yeast has evolved mechanisms that allow it to generate and tolerate levels of ethanol that are sufficiently high (7–9% in many fermentations) to inhibit the growth of most competing microbes, and to be of beneficial use to man. From our point of view, the critical adaptation evolved by yeast concerns its ability first to synthesize ethanol (by fermentation, which can occur even under aerobic conditions) and later to consume it (by respiration). This is achieved by the differential regulation of two duplicated alcohol dehydrogenase genes, *ADH1* and *ADH2*, which encode for two alcohol dehydrogenases (ADHs), ADH1 and ADH2, that interconvert ethanol and acetaldehyde.

Today, in much of the developed world, the production of alcoholic beverages is manifested as a massive, globalized industry that relies upon ongoing advances in our knowledge of the biochemistry, physiology and molecular biology of yeasts.

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Concomitant with this is a plethora of smaller, more artisanal industries doing essentially the same thing, but with very little cognisance of the scientific niceties of that important micro-organism.

Ethanol is a relatively simple chemical compound, yet it is astounding to see the many different ways in which people use, perceive and react to the substance. Most anthropologists and ethnologists would agree that ethanol has long been one of the most widespread chemical compounds encompassed by mankind. Its potential roles are many-fold, since it can act as a disinfectant, an anaesthetic, a tranquilizer, an appetizer, a food, a solvent and an economic commodity, as well as being a potent symbol in many cultures.

The present work represents an attempt to provide a basis for further research into the significance of alcoholic beverages in the advancement of mankind. It attempts to integrate some of the botany, ethnobotany and history of important providers of fermentable material with the role of the microbial world in the production of some widely used, non-distilled, alcoholic drinks. Due regard has been paid to the relevant information we have gleaned from the relatively new field of genomics, and it will, hopefully, give an indication of how genome-related work has transformed the scientific community.

The book deals solely with non-distilled beverages, and pressure on space demanded that this should be the case. Important beverages though whisky, gin, vodka, *etc.* are, products of the art of distillation were one of man's more recent (albeit very effective) means of achieving insobriety. I trust that this omission does not detract from the usefulness of the book. While on the subject of omissions, for similar, spatial, reasons I have not been able to do justice to the role of the fig and the date palm (and several other plants) as sources of fermentable sugar. Another, possibly contentious, point is my decision to include *chicha* in the section dealing with cassava rather than maize.

Regarding dating, I have used the dating systems adopted by various authorities when quoting their work. For an erudite account of how the various systems are interrelated, see Zohary and Hopf (reference 16, page 15).

I have been lucky to have had the use of two of the greatest libraries in the world: the British Library and the Cambridge

University Library (at both the Central Science and West Road sites). Staff at the latter have, as always, been particularly helpful, and I am particularly indebted to Bill Noblett who responded to my emergency calls with diligence and alacrity.

I am also grateful for the fact that numerous authorities – in varying subject areas – have given helpful assistance, and, in this regard, especial thanks are due to Robin Allaby, John Arthur, Robert Carlson, Alan Clapham, Frances Hayashida, Elizabeth Kellogg, Max Nelson, Mark Nesbitt, Roger Putman, Ian Roberts, José Sampaio, Janet Spitz and Ryan Williams. All of this help was invaluable, but, as ever, any errors are entirely down to me. Finally, I wish to thank my wife for tolerating the strange ways of an author!

Contents

Alcohol and its Role in the Evolution of Human Society
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CHAPTER 1

Introductory Matter

THERE IS ONLY **ONE** HISTORY OF LIFE ON EARTH

Steven A. Benner

There is, and always has been, a never-ending struggle between man and micro-organisms for the opportunity to consume food supplies. These food supplies are ultimately the legacy of the photosynthetic activity of plants. The study of the history of alcoholic fermentation is necessarily multi-faceted, involving basic biological science, the life and culture of ancient peoples, the study of races and their customs and the interactions of plants and humans. Understanding the process of plant domestication is fundamental to our comprehension of the rise of agriculture, and knowledge of the latter is a prerequisite for understanding the importance of alcoholic beverages in the development of mankind.

Before the modern era, only the Eskimos, the peoples of Tierra del Fuego at the southern tip of South America and the Australian aborigines apparently lived out their lives without the medical benefits and mind-altering effects of alcohol. While polar regions generally lacked resources for fermentable monosaccharides, honey and sugar-rich fruits and other plants are plentiful in temperate parts of the globe and the tropics. In the New World, most of North America was devoid of indigenous alcoholic beverages prior to Columbus, while, further south, maize, the juice of the century plant and the saguaro cactus were sweet enough to

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ferment directly into *chicha*, pulque and cactus wine, respectively. As a rule of thumb, the plant species-rich areas of the globe, such as the tropics were/are home to the greatest variety of alcoholic drinks. In Europe, ancient northern peoples were somewhat starved of "available sugar" sources and relied on grains to make their alcoholic drink (beer), while those in southern Europe had recourse to berries (for wine), which would yield fermentable material with far less persuasion.

The major raw materials (fermentable sugars) available to prehistoric man for fermentation purposes would have been the monosaccharides glucose and fructose and the disaccharides sucrose, lactose and maltose. The latter could be obtained from sprouting grain, and lactose is present in milk. The two monosaccharides, and their dimer, sucrose, are invariable components of fruits and honey. It is likely that, where they grew, juice from the fruits of the date palm (*Phoenix dactylifera* L.) and the fig (*Ficus carica* L.) would have been important sources of fermentable sugar.

The date palm was one of the first trees to be taken into cultivation in the Old World.[1] Fossil evidence suggests that fermentable fruits became prominent around 80 million years ago (Mya), in the Cretaceous, during the age of the dinosaurs. The end of the Cretaceous saw, in addition to the emergence of fruits, the extinction of the dinosaurs and the emergence of mammals and fruit flies. Provided that the relevant microbes were available, these sugar-containing fruits could have undergone spontaneous fermentation and thus, in essence, become the "first alcoholic drinks". According to Dilcher,[2] the strongest selection pressure in the angiosperms was directed toward the flower, fruits and seeds.

It is a long-held, almost universal, human belief (albeit in various forms) that alcoholic drinks, particularly wine and beer, were bestowed upon mankind by a deity that took pity on his plight. In many ancient cultures beer was a gift to women from a female deity, and brewing was for centuries intimately connected with the fairer sex (Figure 1.1). Certainly, the promotion of amylolysis in grain by chewing seems to have been (and still is) largely a female occupation (Figure 1.2). There seems to have been scant regard for gender equality in ancient times, for beverage consumption was largely the preserve of males (Figure 1.3)!

Figure 1.1 Nineteenth-century lithograph showing women brewing *chicha* in the town of Arequipa, Peru. After Marcoy, 1873.[3]

Increasing amounts of archaeological, ethnographic and evidence from around the world suggest that alcoholic beverages have been integral to the social, economic, religious and political aspects of many cultures. Feasting activities were especially important,[5] and often marked critical events in the lives of individuals and communities, and frequently involved public rituals.

Figure 1.2 Women chewing maize for *chicha* production. After Marcoy, 1873.