Trends in Analytical Chemistry 64 (2015) 127–135

Contents lists available at ScienceDirect

Trends in Analytical Chemistry

journal homepage: www.elsevier.com/locate/trac

Advances in assessing the elemental composition of distilled spirits using atomic spectrometry

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ARTICLE INFO

Keywords:
Atomic absorption spectrometry
Calibration
Distilled spirits
Elemental analysis
Mass spectrometry
Optical emission spectrometry
Quality assurance
Quality control
Sample preparation
Spectrochemical technique

ABSTRACT

Elements that affect the taste, the smell and the color of distilled spirits can originate from raw materials and utensils used for processing and reach levels from several to hundreds of thousands of µg L^{-1}. Determinations of certain elements in distilled spirits are required to assess their quality and safety and can be used to judge their nutritional value or to verify if finished products conform to specific safety regulations. This review is dedicated to spectrochemical techniques and sample-preparation procedures used in elemental analysis of distilled spirits and covers studies published in the past 20 years. We pay particular attention to sample-treatment procedures and calibration strategies prior to measurements by different atomic spectrometry methods. We also discuss possible sources of elements in distilled spirits and the suitability of the information about elemental contents for identifying and classifying distilled spirits.

Contents

1. Introduction

Distilled spirit products result from distillation of plant or fruit juices (e.g., sugarcane or agave), seeds (anise), or fruits and fruit marcs (grape or blackberry) after previous fermentation. They are popular strong alcoholic beverages (see Fig. 1) served alone or as ingredients of various alcoholic drinks [1–5]. Fig. 2 shows the production process of distilled spirits. As can be seen, major, minor and trace elements in these alcoholic beverages are of primary (natural) and secondary sources. The primary sources of elements are the production region, environmental conditions (soil types and weather conditions) and other natural activities affecting the growth of plants, and fruits and grains and the quality of these raw materials (i.e., fruit and plant juices, seeds and/or pomaces, and grain mashes) [2,5–25]. The secondary sources of elements in distilled spirit products are activities related to cultivation of plants, fruits and grains (e.g., fertilization, agrochemical protection and crop treatment) and production of spirits (e.g., materials and equipment used for maceration, fermentation, distillation and maturation, fabrication and storage, and, finally, technology and manufacturing processes) [2,5–25].

Despite large consumption of distilled spirit products, it seems that inorganic profiles of some of them remain poorly defined and need more extensive investigations [3,19,25,26]. This lack of definition may hinder establishing appropriate standards of market quality and safety of these products and badly affect their characteristics and marketing [25,27,28]. Greater attention to product authenticity and origin, quality control (QC) and suitable

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http://dx.doi.org/10.1016/j.trac.2014.09.004

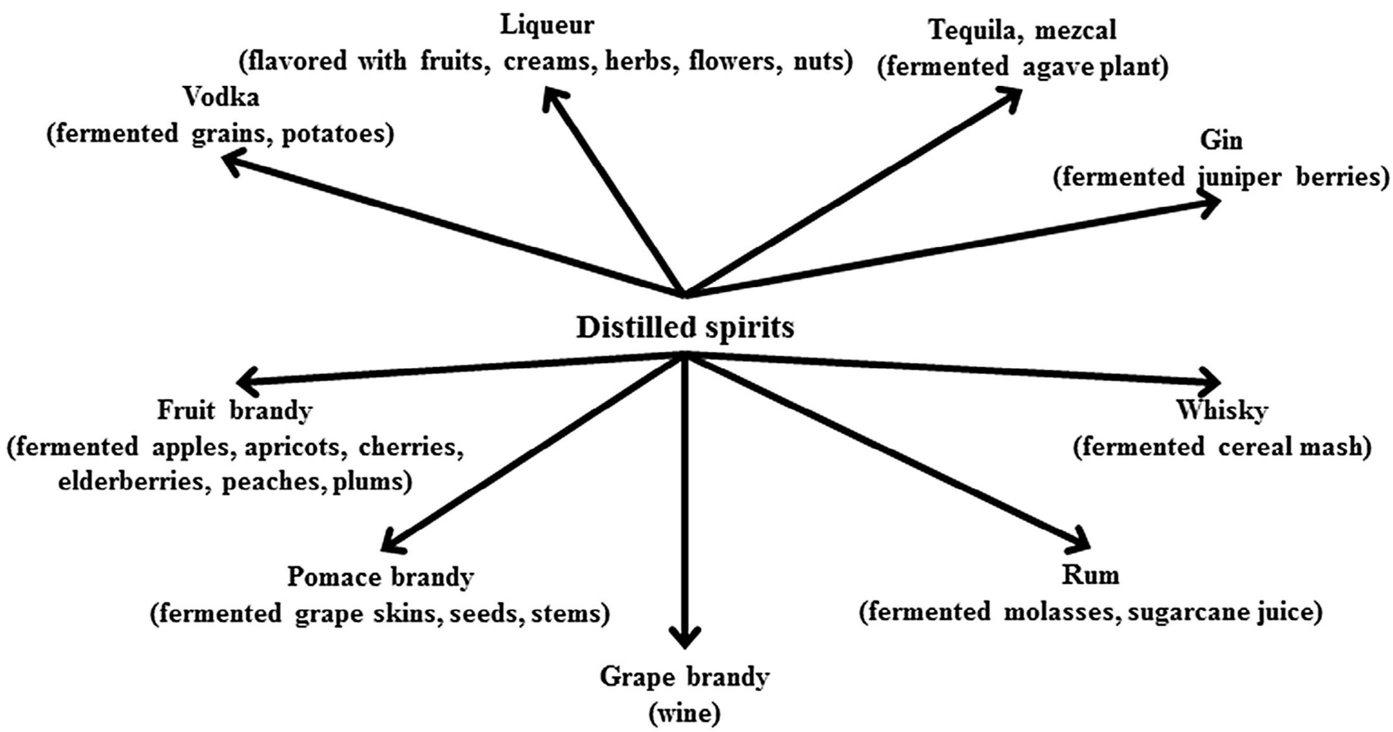

Fig. 1. Different types of distilled spirits.

reference parameters of elemental composition could certainly enhance the safety of these products and benefit the economy of regions dealing with the production and trade of distilled spirits. The presence of selected trace elements (i.e., Al, As, Cd, Cu, Cr, Hg, Ni, Pb, Sb, and Zn) contributes to the overall quality of these alcoholic beverages and determines their suitability and safety for consumption in view of the toxicity of certain elements above tolerable and/or allowable limits [3,5,16,19,24,25,29–33]. In view of this, analysis of distilled spirits is required to assess potential health effects, while the information about concentrations of certain elements is an important parameter of the QC of these products. Usually, the content of potentially hazardous elements is low or even undetectable. However, when it is elevated or the consumption of certain alcoholic beverages is above average, the dietary intake of these elements may reach dangerous levels [20,32].

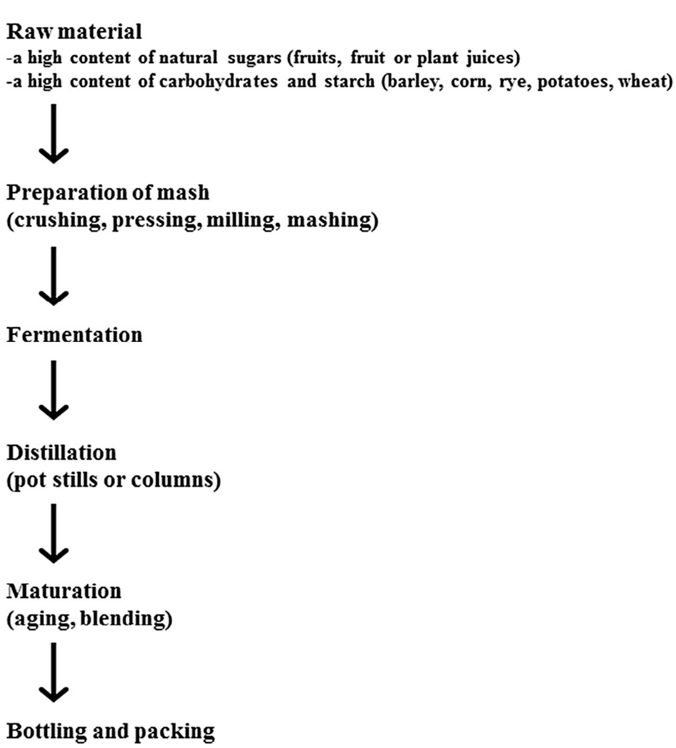

Fig. 2. Production steps of distilled spirits.

To avoid toxic effects on human health from these elements and to preserve the high quality and the safety of final distillates, the composition of these products is controlled by national legislations and stringent regulations [13,25,30]. Accordingly, permissible levels of selected trace elements in these products are given as the following: 10 mg L^{-1}, 10 mg L^{-1}, 0.5 mg L^{-1} and 2 mg L^{-1}, respectively for As, Cu, Pb and Zn [25] in Serbia, 0.1 mg L^{-1}, 5 mg $L^{-1}$and 0.2 mg L^{-1}, respectively for As, Cu and Pb [1,3,6–8,16,31,34,35] in Brazil, 10 mg L^{-1}, 1 mg L^{-1} and 10 mg L^{-1}, respectively for Cu, Pb and Zn [2,5,14], in Spain, and 4 mg $L^{-1}$and 2 mg L^{-1}, respectively for Cu and Fe [13,27] in Venezuela. Apart from verification of the quality and the safety of distilled spirits, their reliable elemental analysis is important from a marketing point of view {i.e., to guarantee the products are genuine and of superior quality, particularly when these products are declared as possessing a certified brand of origin (CBO) label [1,2,6,7,29,36,37]}.

2. Elements in distilled spirits

The elemental compositions of distilled spirits vary depending on the raw materials used for their production, and the materials from which the equipment and the facilities used for production are made [14,26,27,38]. As can be seen from Tables 1 and 2, K, Na and Ca are present in the highest concentrations [2,5,9–12,24,36,38]. High content of these elements along with Li and Mg is often related to the quality of water used for dilution of distillates [2,3,9,10,16,31,38] and/or wooden barrels and casks used for aging