Available online at www.sciencedirect.com
SCIENCE DIRECT®
Food Chemistry 92 (2005) 673–679
Food Chemistry
www.elsevier.com/locate/foodchem

A study of the relationships among acidity, sugar and furanic compound concentrations in set of casks for Aceto Balsamico Tradizionale of Reggio Emilia by multivariate techniques

Francesca Masino [a], Fabio Chinnici [b], Gian Carlo Franchini [a], Alessandro Ulrici [a], Andrea Antonelli [a,*]

[a] *Dip. Interdisc. Sc. Agrarie, Via J.F. Kennedy 17, 42100 Reggio Emilia, Italy*
[b] *Dip. Sc. Alim., Via Fanin 40, 40127 Bologna, Italy*

Received 23 February 2004; received in revised form 23 August 2004; accepted 23 August 2004

Abstract

''Aceto Balsamico Tradizionale'' (ABT) is gaining increasing attention due to its peculiar characteristics, not only within the production area. A first approach to understanding the complex ageing process was performed by studying ABT furanic compounds, quantified by HPLC: hydroxymethylfurfural, furoic acid, furfural, and 5-acetoxymethylfurfural (HMF, FA, Fal, AMFA). Also, other parameters, expressing the acidic and sugar contents (pH, total acidity and °Brix), were quantified.

Furanic compounds arise during the must concentration process. Moreover, they tend to rise on ageing, as a consequence of the water loss during the process. However, due to the great reactivity of these substances, which rapidly evolve into other compounds, differences in the accumulation kinetics are likely.

While the separate analyses of the single variables did not lead to any significant contribution in the understanding of the phenomena involved in the product transformation, principal component analysis showed a common trend on ageing for all the studied sets.

Keywords: Aceto balsamico tradizionale; Traditional balsamic vinegar; ABT; Chemometrics; Principal component analysis; Vinegar; 5- Hydroxymethylfurfural

1. Introduction

The ''Aceto Balsamico Tradizionale'' (traditional balsamic vinegar) of Reggio Emilia (ABT) is a typical product of the Emilia Romagna region in the north of Italy. It is produced by slow ageing of cooked must from local grapes, for at least 12 years (G.U., 1986) in sets of casks of decreasing volume and made of different woods. Once a year, a portion of the final product is drawn from the smallest barrel (cask No. 1 in Fig. 1), which is refilled with the content of the previous one (cask No. 2). The practice is carried out up to the largest barrel (cask No. 5), which is eventually filled with fresh cooked must. On ageing, the product undergoes a further slow concentration process by water evaporation through the staves. Moreover, in the first barrels, an alcoholic oxidation and a subsequent acetic oxidation occur. In the following barrels, contents (a_w, acetic acid concentration, acidity) prevent any further biological activity. The final result is a thick dark syrup, which is very appreciated as a sauce for adding to many different gastronomic products (e.g., parmesan, meat, salad, strawberries.) with a characteristic and pleasant aroma. Further details about the ABT production technique can be found in previous literature

* Corresponding author. Tel.: +39 522 300531; fax: +39 522 301482.
E-mail address: andrea.antonelli@unimo.it (A. Antonelli).

0308-8146/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2004.08.029

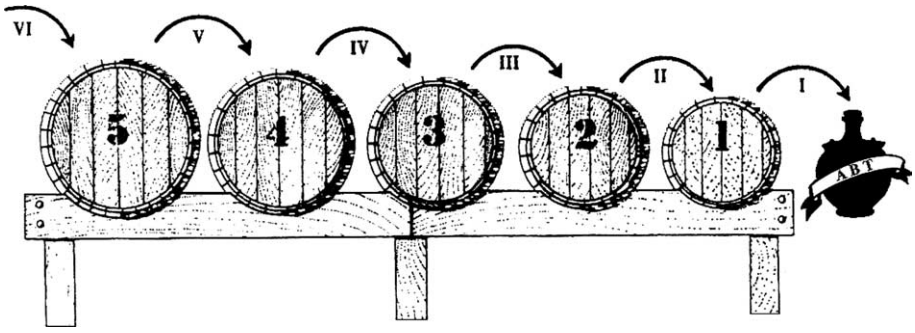

Fig. 1. A typical set of barrels for "Aceto Balsamico tradizionale" (ABT) production. Arabic numerals identify each cask, while Roman numerals indicate the sequence of the drawing procedure.

(Cocchi, Lambertini, Manzini, Marchetti, & Ulrici, 2002). In a previous paper (Antonelli, Chinnici, & Masino, 2004), some of us demonstrated that must concentration was responsible for a variety of sugar degradation products, the most important being hydroxymethylfurfural (HMF). This substance is formed in many heat-processed products (Lee & Nagy, 1990; Morales, Romero, & Jimenez-Pérez, 1992). The heat concentration process of grape must is the main HMF source, but there is evidence that this compound, and its congeners, slowly increases at room temperature as also in minimally heat-processed foods. Honey (Salinas, Mansilla, & Nevado, 1991), fruit juices (Maijares, Park, Nelson, & McIver, 1986) and wine (Williams, Humphreys, & Reader, 1983) are a few examples where this formation occurs. Besides HMF, must cooking yields some other furanic congeners: furoic acid (FA), furaldehyde (Fal) and acetoxymethylfurfural (AMFA) (Antonelli et al., 2004). Until now, the variations in concentration of these compounds during ageing and along the cask sets have not been described in the scientific literature.

In order to interpret such a complex process, we used a multivariate approach, i.e. principal component analysis (PCA), which allows concentration of the information of the data set into a reduced number of variables (Massart et al., 1997).

In particular, the evolution of some main composition parameters (pH, total acidity, °Brix, along with furanic compounds) was studied in sets of barrels used for ABT production. PCA showed an ageing pattern common to almost all the analysed sets, but it also emphasised the peculiarity of some of them.

2. Materials and methods

2.1. Samples

Seven sets (composed of five casks each), representative of the ABT production area, were chosen. The sets were managed strictly, following the classical method described in Section 1. A 100 ml sample aliquot was taken from each barrel at the moment of ABT drawing, as described previously.

According to tradition, barrels are numbered as shown in Fig. 1, i.e. from the smallest one to the largest one: cask No. 1 contains the oldest product (ABT), while in cask No. 5 the cooked must starts its ageing.

2.2. Physical and chemical determinations

Undiluted samples were used for pH and °Brix measures, which were carried out with a pH meter and a refractometer, respectively. Total acidity was measured by the titrimetric method for wine and must analyses.

FA, HMF, Fal and AMFA were determined by an HPLC method previously published (Chinnici, Masino, & Antonelli, 2003), using a cation exchange column isocratically operating and diode array detection.

Multivariate analysis of data was carried out in the MATLAB ver. 6.5 environment (MathWorks Inc., Natick, MA, USA), using the routines of the PLS Toolbox 2.1 (Eigenvector Inc., Natick, MA, USA).

3. Results and discussion

Table 1 summarises the analytical results of the considered samples. Sugar concentration (°Brix) ranged from 21.3 (cask 5, set A) to 72.5 (cask 1, set F). This parameter showed an increase, on ageing, for sets A, D, E, F, and G, but the same trend was not observed for sets B and C. When considered separately, the values of pH, which varied from 2.02 (cask 1, set F) to 3.50 (cask 3, set F), and total acidity, that ranged from 1.76 g/100 g (cask 5, set A) to 6.72 g/100 g (cask 1, set A), did not yield useful information.

As a consequence of sugar degradation, must cooking generates a great amount of furanic compounds (Antonelli et al., 2004). In many cases, HMF was above 3 g/kg. In five sets (A, D, E, F, and G), HMF increased regularly along the cask series, reaching final concentrations up to six times those of the barrel containing the youngest product (from 246 to 1441 mg/kg for set A).