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Antioxidant, antimicrobial, mineral, volatile, physicochemical and microbiological characteristics of traditional home-made Turkish vinegars

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ABSTRACT

In the current study, twenty traditional home-made vinegars collected from different regions of Turkey were characterized in terms of their antioxidant, antimicrobial, mineral and volatile profiles as well as their physicochemical and antimicrobial properties and microbiota. The vinegars were compared to five industrial vinegars according to the characterized properties. Industrial vinegars showed quite high antimicrobial activity while only three traditional vinegars had antimicrobial activity for the all test microorganisms. With respect to these results, traditional vinegars had generally high microbial load; however, they were scarcely detected in industrial vinegars. Physicochemical properties of all vinegars were extremely variable. A total of 61 volatile compounds were determined in the traditional vinegars. The most abundant compounds were α-terpineol and ethyl acetate in some traditional vinegars, while phenethyl alcohol was a common compound detected in the vinegars. Mineral profile of traditional vinegar was determined by using ICP-MS. The most abundant minerals were Na, K and Ca in the vinegars. As a conclusion, traditional Turkish vinegars exhibited very distinct properties independent from raw materials used.

1. Introduction

Vinegar is a fermented food that is produced by fermentation of fruits and vegetables containing sugar or starch. Vinegar production is composed of a two-stage fermentation process, namely alcohol fermentation and acetic acid fermentation. First stage is alcohol fermentation during which fermentable sugars are converted to ethanol and CO_2 under anaerobic conditions by yeasts which are generally composed of *Saccharomyces* species. Second stage is acetic acid fermentation where the alcohol formed in the first stage is converted to acetic acid and water under aerobic conditions by acetic acid bacteria including *Acetobacter aceti, A. pastorianus* ve *A. hansenii* (Plessi, 2003). Commercial vinegar production is performed with fast or slow fermentation processes. In the fast method, the liquid of damaged fruits is oxygenated and fermentation process is rapidly carried out by submerging the bacterial starter culture. However, slow method is generally used for production of traditional wine vinegars and may take about over the course of weeks or months. In this process, a nontoxic slime that is known as the *mother* of vinegar comprise yeast and acetic acid bacteria on the surface (Johnston & Gaas, 2006).

Vinegar has a diversity of uses such as seasoning, salad dressing and flavoring for foods. On the other hand, it has been also used as a health remedy since ancient times (Tan, 2005). Today, it is well known that vinegar has a number of therapeutic activities including anti-infective properties, antitumor activity and blood glucose control (Johnston & Gaas, 2006). The presence of phenolic compounds in vinegar also provides positive health effects which originate from their antihypertensive effect and strong antioxidant activity (Dávalos, Bartolomé, & Gómez-Cordovés, 2005). In addition, potential of vinegar as a medicinal remedy has been attributed to the presence of essential amino acids, vitamins, minerals, organic acids and other polyphenols (Adams, 1997).

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Vinegar has its unique flavor and aroma which are mainly resulted from acetic acid fermentation. Acetic acid which has a pungent flavor is responsible for the basic sensorial characteristic of vinegar. However, other vinegar constituents including organic acids, volatile compounds and other fermentation products also play a role on its organoleptic properties. Diluted acetic acid is not considered as vinegar and when used as an ingredient in food products, it should be declared by its name (FDA, 1989). Vinegars obtained from different sources may have different quality characteristics. Acetification system (fermentation conditions) is also effective on the final quality of vinegar while chemical composition and physicochemical parameters are influenced by these factors (Tesfaye, Morales, Garcıa-Parrilla, & Troncoso, 2002). In spite of the variability in many quality parameters, some general rules about several characteristics such acidity level and presence of heavy metals of vinegars have been established in national and international scale to arrange the commercialization. Therefore, the aim of this study was to characterize the home-made traditional and industrial vinegars manufactured in Turkey with respect to their physicochemical (acidity, turbidity, pH, color and brix), microbiological (lactic acid bacteria, acetic acid bacteria and yeast-mold counts) and bioactive properties, antimicrobial activity, mineral and volatile composition.

2. Materials and methods

2.1. Material

Twenty five vinegar samples were collected from various cities in Turkey. Twenty vinegars collected were traditionally home-made and the rest of the samples were industrially produced.

2.2. Physicochemical properties

pH values of the vinegars were measured by using a pH meter (InoLab 720, WTW GmbH, Weilheim, Germany) calibrated with buffer solutions (Akbas & Cabaroglu, 2010).

A ten mL of vinegar was mixed with 20 mL of distilled water and the mixture was titrated up to pH:8.2 by using 0.1 M NaOH. Total acidity was expressed as acetic acid equivalent (Akbas & Cabaroglu, 2010).

Brix values of the vinegars were measured using Abbe refractometer (Reichert, Benchtop Refractometers AR 700, New York, USA) calibrated with distilled water. The values were expressed as Brix (Akbas & Cabaroglu, 2010).

Turbidity values of the vinegars were determined using a turbidimeter (Hach Turbidimeter 2100N, Colorado, USA) (López et al., 2005). The values were expressed as NTU (Nepholometric Turbidity Unit).

Color values of the vinegars were measured using a chromameter (Lovibond RT Series Reflectance Tintometer, Amesbury, UK) calibrated with standard calibration scale (El Sheikha, Zaki, Bakr, El Habashy, & Montet, 2010). They were expressed as L^* (whiteness/darkness), a^* (redness/greenness), and b^* (yellowness/blueness).

2.3. Total phenolic content

Total phenolic content (TPC) of the vinegars was determined according to Folin-Ciocalteu method described by Singleton and Rossi (1965). Vinegar samples were filtered using a filter of 0.45 μm and appropriately diluted. A four mL of the filtrate was mixed with 2 mL of Folin Ciocelteau's phenol reagent and 1.6 mL of Na_2CO_3 (7%) and the final mixture was incubated at the room temperature for 90 min. After the incubation, absorbance of the mixture was measured using a spectrophotometer (Shimadzu UV–visible 1700, Tokyo, Japan) at 760 nm. TPC was expressed as mg gallic acid equivalent (GAE)/L.

2.4. Total flavonoid content

Total flavonoid content (TFC) of the vinegars was determined according to the method described by Zhishen, Mengcheng, and Jianming (1999). Vinegar samples were filtered using a filter of 0.45 μm and 1 mL of filtrate was mixed with 4 mL of distilled water. It was mixed with 0.3 mL of $NaNO_2$ (5%), 0.3 mL of $AlCl_3$ (10%) and 2 mL of NaOH (1 M) and the total volume of mixture was finalized to 10 mL by distilled water. The absorbance of mixture was measured at 510 nm using a spectrophotometer (Shimadzu UV–visible 1700, Tokyo, Japan). TFC was expressed as catechin equivalent.

2.5. Antiradical activity

The antiradical activity of the vinegars was determined as free DPPH radical scavenging capacity (Singh, Chidambara Murthy, & Jayaprakasha, 2002). Vinegar samples were filtered using a filter of 0.45 μm and 0.1 mL of filtrate was mixed with 5 mL of DPPH solutions (0.1 mM) and vigorously mixed with vortex. Following the incubation for 13 min at 27 °C in dark conditions, absorbance of the mixture was measured at 517 nm using a spectrophotometer. Antiradical activity (ARA, %) was described as following Eq. (1):

$$ARA(\%) = \left(\frac{A_c - A_S}{A_c}\right) \times 100 \quad (1)$$

where A_c and A_s is absorbance of control (DPPH solution) and the sample, respectively.

2.6. Antimicrobial activity

Antimicrobial activity of the vinegars was determined by using agar diffusion method against 10 microorganisms (*Escherichia coli* ATCC 25922, *Listeria monocytogenes* ATCC 7644, *Salmonella enterica* subsp. *typhimurium* ATCC 14028, *Yersinia enterocolitica* ATCC 27729, *Staphylococcus aureus* ATCC 25923, *Bacillus cereus* ATCC 33019, *E. coli* O157:H7 ATCC 33150, *Klebsiella pneumonia* ATCC 13883, *Pseudomonas aeruginosa* ATCC 17853 and *Proteus vulgaris* ATCC 13319). Vinegar samples were purified from bacteria by using membrane filter (0.22 μm). Mueller-Hinton Agar was sterilized using autoclave. The agar was cooled to 45–50 °C and 1% of fresh bacterial culture was added. The agar containing bacteria was mixed and poured into plates. After the plates hardened, they were holed about 6 mm pore using cork borer. Sterile-filtered vinegar samples were added to the wells. Plates were incubated at 37 °C for 24 h and zones around the wells were measured in mm (Sagdic et al., 2013).

Table 1
Microwave oven program.

Initial temperature (°C)	Final temperature (°C)	Time (min)
25	90	5
90	90	5
90	120	5
120	120	5
120	150	5
150	150	5
150	175	5
175	175	5