LAB-ON-A-DISC FOR SIMULTANEOUS DETERMINATION OF TOTAL PHENOLIC CONTENTS AND ANTIOXIDANT ACTIVITY IN BEVERAGE SAMPLES

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ABSTRACT

We present a fully automated lab-on-a-disc designed for the rapid determination of total phenolic contents (TPC) and antioxidant activity (AA) in beverage samples. Taking advantages of lab-on-a-disc in simple operation, automation, we integrated two methods; Folin-Ciocalteu (FC) method and ferric reducing antioxidant power (FRAP) method for determining TPC and AA, respectively. Compared to a conventional manual TPC and AA detection methods, our platform show reduced analysis time by 9 times for FC and 3 times for FRAP. Our device successfully detected and compared the TPC and AA from 8 different beverage samples including various fruit juice, tea, wine, and beer.

KEYWORDS: Total phenolic contents, Antioxidant activity, beverage, Lab-on-a-disc

INTRODUCTION

As the issue of well-being and the quality of life is gaining attention, the amount of antioxidants incorporated in food and beverages have become a decisive factor in consumption. The presence of natural antioxidants in food and beverages, such as total phenolic compound (TPC) and its antioxidant activity (AA), has attracted considerable interest because of its potential health-aid and therapeutic effects [1]. Conventionally, TPC and AA detection were conducted using expensive and locally fixed

Figure 1. Real picture of (A) our disc, and schematic illustration of (B) the detail design of microfluidic layout showing the chambers for reagent storage and sample injection. The number 1-8 represent LIFMs and (C) reaction mechanism of a. FC and b. FRAP method for detecting Total Phenolic Contents (TPC) and Antioxidant Activity (AA).
instruments such as high performance liquid chromatography (HPLC) or using colorimetric methods. HPLC analyses are powerful for separating and identifying the TPC in the sample but it is both time-consuming and expensive. Colorimetric methods such as FC and FRAP [2] are recommended for frequent analysis because it is more cost-effective, but this method requires manual processing, and in the case of handling a large amount of samples, it becomes laborious and time consuming. In this study, we developed a simultaneous TPC and AA analysis platform integrating FC and FRAP method on a lab-on-a-disc.

**EXPERIMENTAL**

The disc layout and scheme of colorimetric TPC and AA analysis are shown in Figure 1. Using pressure sensitive adhesives, three different disc layers were assembled. In Figure 1B, functionalized chambers for filtration, reagent storage, and assay solution and detection chambers were connected between the channels. The flow of fluids was controlled by using laser irradiated ferrowax microvalves (LIFM), which uses ferro-oxide irradiation by laser to melt the wax to open the fluidic passage. As shown in Figure 2, whole procedures of FC and FRAP methods for TPC and AA detection from beverage samples were fully integrated on a disc, standard calibration curves of FC and FRAP methods was obtained in Figure 3. TPC and AA analysis was conducted using our lab-on-a-disc system for 8 different beverage samples are depicted in Table 1. Among them, red wine showed the highest TPC and AA whereas beer showed the lowest.

![Figure 2](image)

Figure 2. Integrated processes for TPC and AA determination on a disc. (A) loading the beverage sample, diluting water, FC reagent, Na2CO3 and FRAP reagent in a disc (B) spinning down the colloidal particle from the beverage sample (C) metering the sample (D) Discarding the remaining sample and colloidal particle to waste chamber and transferring the sample to dilution chamber (E) transferring diluted sample to FC reaction chamber and mixing and then, (F) transferring the solution to Na2CO3 containing chamber (precipitation occurs) (G) spinning down the precipitated particles in the bottom of chamber and then (H) transferring supernatant solution to detection chamber, and starting FRAP reaction as transferring diluted sample to FRAP solution containing chamber simultaneously. Finally detecting the colorimetric signals from each detection chamber using optical fiber coupled portable spectrometer.
CONCLUSION

A fully integrated lab-on-a-disc was developed for the determination of TPC and AA from beverage samples. Our lab-on-a-disc system can be used for rapid and simple determination of TPC and AA from the beverage samples on site. We expect that our device to be presented to the beverage making companies as providing a fast and cost-effective ingredient analysis and also aid the customers to in selecting beverages for their well-being.

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REFERENCES


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Table 1. TPC and AA analysis results from 8 different beverage samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>FC method (TPC)</th>
<th>FRAP (AA)</th>
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<tbody>
<tr>
<td>1. Green tea</td>
<td>422.3 mg/L</td>
<td>8.4 mM</td>
</tr>
<tr>
<td>2. Black tea</td>
<td>245.7 mg/L</td>
<td>2.9 mM</td>
</tr>
<tr>
<td>3. Orange juice</td>
<td>529.6 mg/L</td>
<td>1.9 mM</td>
</tr>
<tr>
<td>4. Grape juice</td>
<td>1023.6 mg/L</td>
<td>9.6 mM</td>
</tr>
<tr>
<td>5. Apple juice</td>
<td>615.0 mg/L</td>
<td>8.6 mM</td>
</tr>
<tr>
<td>6. Red wine</td>
<td>1350.9 mg/L</td>
<td>23.2 mM</td>
</tr>
<tr>
<td>7. White wine</td>
<td>1293.5 mg/L</td>
<td>2.4 mM</td>
</tr>
<tr>
<td>8. Beer</td>
<td>187.1 mg/L</td>
<td>1.4 mM</td>
</tr>
</tbody>
</table>

Figure 3. Standard calibration curves for (A) FC method and (B) FRAP method