

Article

Evaluation of Antioxidant Activities of Different Kinds of Cauliflower

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Abstract: Cauliflower is a vegetable with rich nutritional properties, and cultivated widely. The antioxidant activities, total phenolic contents (TPC) and total flavonoid contents (TFC) of different kinds of cauliflower were evaluated and compared, including purple cauliflower, green cauliflower and white cauliflower. The antioxidant activities of 50% ethanol and 80% methanol extracts of three kinds of cauliflower were evaluated using ferric-reducing antioxidant power (FRAP) and Trolox equivalent antioxidant capacity (TEAC) assays, respectively. The TPC and TFC values of the extracts from three kinds of cauliflower were determined by the Folin-Ciocalteu method and $AlCl_3$ colorimetry, respectively. The results showed that purple cauliflower curds possessed the highest FRAP, TPC and TFC values. This study was helpful for the public to select cauliflower.

Keywords: cauliflower; antioxidant activity; phenolics; flavonoid.

1. Introduction

Many studies have shown that vegetables and fruits possessed various health benefits for human beings (Shang et al., 2021; Tao et al., 2020; Yang et al., 2021; Zhou et al., 2021). Cauliflower (*Brassica oleracea* L. var. botrytis) is one of the most important varieties of *B. oleracea*, and has been planted worldwide due to its high nutrition value. Cauliflower contains various bioactive components, such as polyphenols, glucosinolates, sulforaphane, carotenoids, tocopherols, and ascorbic acid (dos Reis et al., 2015; Volden et al., 2009). The presence of these bioactive compounds, especially polyphenols, confers cauliflower a variety of health benefits, such as antioxidant, anti-obesity, cardio-protective and anticancer effects (Ahmed & Ali, 2013; Hwang & Lim, 2015; Koksai & Gulcin, 2008;

Manchali et al., 2012). In this study, the antioxidant capacities of curds and stems from three kinds of cauliflower were measured, and their total phenolic contents and total flavonoid contents were also evaluated. This study could be valuable for consumers to select cauliflower with high antioxidant activity.

2. Materials and Methods

2.1. Chemicals and Materials

The Folin-Ciocalteu's phenol reagent, 2,4,6-tri(2-pyridyl)-s-triazine (TPTZ), 2,2'-azinobis (3-ethylbenothiazoline-6-sulphonic acid) diammonium salt (ABTS), and 6-hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid (Trolox) were purchased from Sigma-Aldrich (St. Louis, MO, USA). Ethanol, methanol, iron(II) sulfate heptahydrate, potassium persulfate, iron(III) chloride hexahydrate, aluminum chloride, and sodium carbonate were bought from Damao Chemical Factory (Tianjin, China). All chemicals used in the experiments were of analytical grade, and double distilled water was used. The three kinds of cauliflower (purple, green and white cauliflowers) are commonly consumed varieties in China, and were purchased from local markets in Guangzhou, China.

2.2. Sample Extraction

The cauliflower curds were separated from the stems. Both cauliflower curds and stems were washed with double distilled water and dried at room temperature. The cauliflower curds and stems were ground into particles using a special grinder for food processing, respectively. The 1.000 g sample was weighed and extracted with 20 mL 80% methanol (or 50% ethanol) in an oscillating water bath for 24 h at room temperature. After extraction, the sample was centrifuged at 4,200 g for 10 min, and the supernatant was collected for subsequent experiments.

2.3. Determination of Total Phenolic Contents

The total phenolic contents (TPC) of cauliflower extract was tested by the Folin-Ciocalteu method (Liu et al., 2018; Tang et al., 2018). Briefly, 500 μ L of the appropriately diluted sample was mixed thoroughly with 2.5 mL of 0.2 mol/L Folin-Ciocalteu reagent for 4 min, followed by the addition of 2 mL saturated sodium carbonate solution (approximately 75 g/L). The mixture was allowed to stand for 2 h of reaction at room temperature, and the absorbance was measured at 760 nm, and the result was expressed as mg GAE/g FW.

2.4. Determination of Total Flavonoid Contents

The total flavonoid contents (TFC) of cauliflower extract was measured according to the literature (Liu et al., 2018; Tang et al., 2018). Briefly, 500 μ L of the appropriately diluted sample was orderly mixed with 1.5 mL ethanol (95%, v/v), 0.1 mL aluminum chloride (10%, w/v), 0.1 mL potassium acetate (1 mol/L), and 2.8 mL double distilled water. The mixture was allowed to stand for 30 min at room temperature, and the absorbance was measured at 415 nm. The total flavonoid content was calculated from a calibration curve, and the result was expressed as mg QE/g FW.

2.5. Determination of Ferric-Reducing Antioxidant Powers

The ferric-reducing antioxidant powers (FRAP) of cauliflower extract was measured as described earlier (Liu et al., 2018; Tang et al., 2018). Briefly, the FRAP reagent, a mixture of sodium acetate-acetic acid buffer (300 mmol/L), ferric chloride solution (20 mmol/L) and TPTZ (10 mmol/L) at a volume ratio of 10:1:1, was freshly prepared and put in a water bath at 37 °C before use. The 100 μ L of the appropriately diluted sample was mixed with 3 mL FRAP reagent. The mixture was incubated for 4 min, and the absorbance was measured at 593 nm. The result was expressed as μ mol Fe²⁺/g FW.

2.6. Determination of ABTS Free Radical Scavenging Activity

The ABTS free radical scavenging activity of cauliflower extract was measured by the Trolox equivalent antioxidant capacities (TEAC) assay as described earlier (Liu et al., 2018; Tang et al., 2018). Briefly, the potassium persulfate (2.45 mmol/L) and ABTS (7 mmol/L) solution were mixed at a volume ratio of 1:1 to prepare the ABTS^{•+} stock solution, and incubated in dark at room temperature for at least 16 h and was effective within 2 days. The stock solution was diluted to an absorbance of 0.710 ± 0.050 at 734 nm with ethanol. The 100 μ L of the appropriately diluted sample was mixed with 3.8 mL ABTS reagent at room temperature for 6 min, and the absorbance was measured at 734 nm. The result was expressed as μ mol Trolox/g FW.

3. Results and Discussion

3.1. Total Phenolic Contents of Cauliflower

The total phenolic contents (TPC) of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers are shown in Figure 1. The effects of extraction solvents on TPC values were different for various cauliflower samples. The methanol extract of purple cauliflower curd showed the highest TPC value among six extracts.

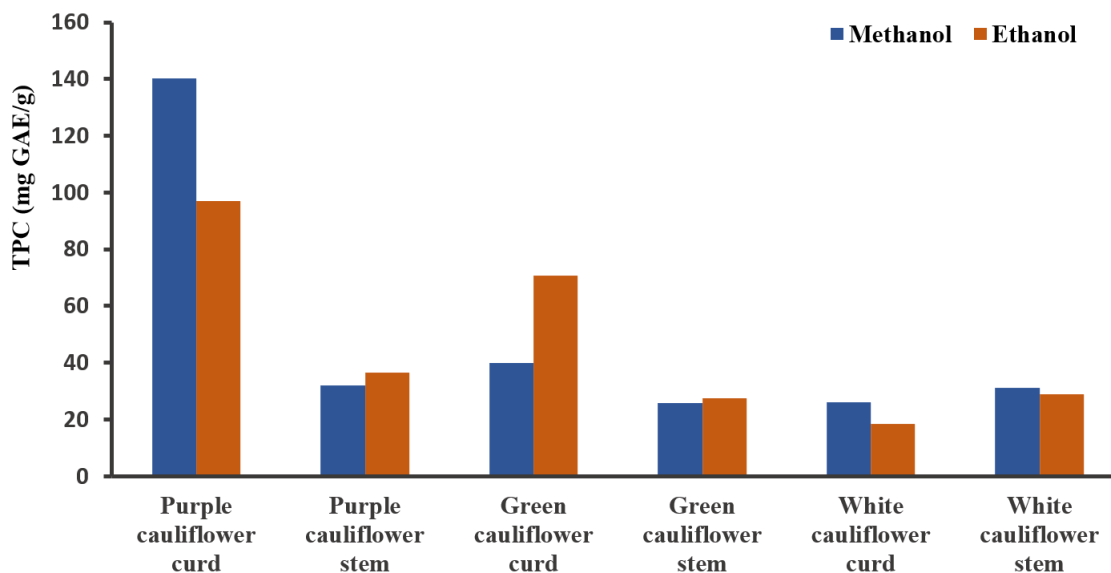


Figure 1. The total phenolic contents (TPC) of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers.

3.2. Total Flavonoid Contents of Cauliflower

The total flavonoid contents (TFC) of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers are exhibited in Figure 2. Generally, methanol showed better extraction efficiency than ethanol, and the cauliflower curds possessed higher TFC values than those of cauliflower stems. In addition, the methanol extract of purple cauliflower curd exhibited the highest TFC value among six extracts. Furthermore, the TPC value was associated with TFC value ($R^2 = 0.8252, p < 0.05$, Table 1), which indicated that flavonoids could be a main contributor of phenolics.

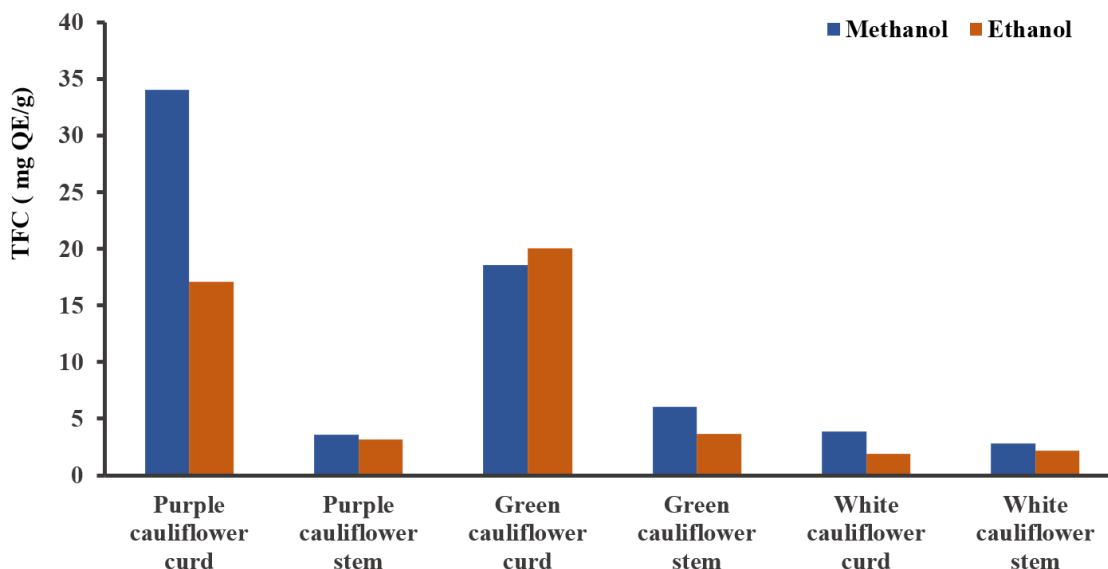


Figure 2. The total flavonoid contents (TFC) of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers.

Table 1. The relation of different parameters

| | Equation | R ² | p value |
|---------------|---------------------------|----------------|---------|
| TPC vs. TFC | $y = 3.2433x + 16.2390$ | 0.8252 | < 0.05 |
| TPC vs. FRAP | $y = 0.0757x + 17.4763$ | 0.9399 | < 0.001 |
| TPC vs. TEAC | $y = -0.2298x + 174.6294$ | 0.9556 | < 0.001 |
| TFC vs. FRAP | $y = 0.0192x + 2.0531$ | 0.7687 | 0.3301 |
| TFC vs. TEAC | $y = -0.0595x + 42.6179$ | 0.8190 | < 0.001 |
| TEAC vs. FRAP | $y = -0.3259x + 682.3826$ | 0.9632 | < 0.001 |

3.3. Ferric-Reducing Antioxidant Power of Cauliflower

The ferric-reducing antioxidant power (FRAP) values of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers are shown in Figure 3. The extraction solvent methanol showed better extraction efficiency than ethanol for the most samples. Additionally, the cauliflower curds had higher FRAP values than those of cauliflower stems for purple and green cauliflowers. Moreover, the methanol extract of purple cauliflower curd showed the highest FRAP value among six samples. Furthermore, the FRAP value was correlated with TPC value ($R^2 = 0.9399, p < 0.001$, Table

1), which indicated that phenolics could be a main contributor of cauliflower reducing ability (Fu et al., 2011).

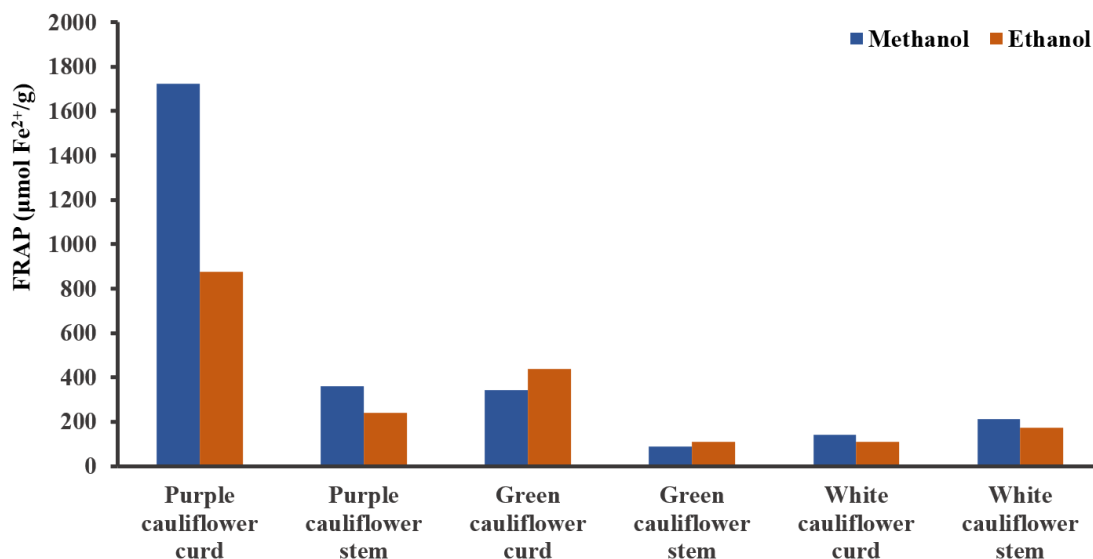


Figure 3. The ferric-reducing antioxidant power (FRAP) value of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers.

3.4. ABTS Free Radical Scavenging Activity of Cauliflower

The ABTS free radical scavenging activities (TEAC values) of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers are shown in Figure 4. The extraction efficiencies of methanol were similar to those of ethanol except purple cauliflower curd. Generally, the cauliflower stems possessed higher TEAC values than those of cauliflower curds. In addition, the green cauliflower stem and white cauliflower stem as well as white cauliflower curd showed similar TEAC values, which were higher compared with other three samples.

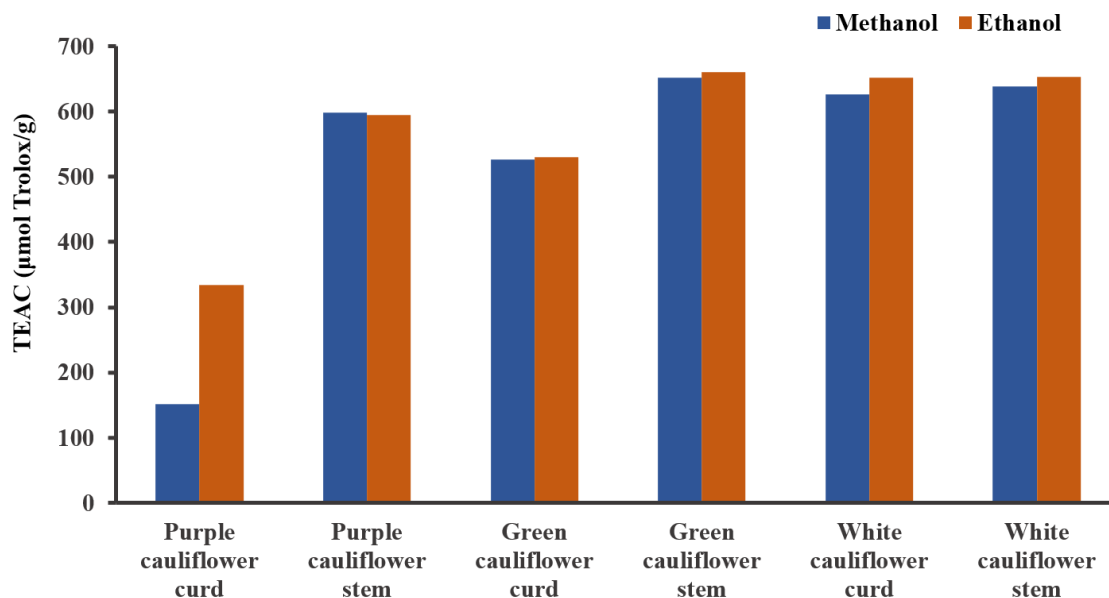


Figure 4. The ABTS free radical scavenging activity (TEAC value) of 50% ethanol and 80% methanol extracts of curds and stems from three cauliflowers.

4. Conclusions

The antioxidant activities, total phenolic contents and total flavonoid contents of curds and stems from three cauliflowers have been evaluated. The purple cauliflower curds showed the highest FRAP, TPC and TFC values among six samples. Additionally, the green cauliflower stem as well as white cauliflower stem and curd possessed similar TEAC values, which were higher than those of other samples. These results were helpful for the consumer to select cauliflower.

Potential Conflicts of Interest

The authors declare no conflict of interest.

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