Comparison of physicochemical and antioxidant properties changes during wine fermentation from three onion varieties

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Abstract. Onion is a vegetable member of the genus Allium and one of the major sources of flavonoids in diets. Wine fermentation is one of the oldest preservation methods, which has been applied mostly on fruits. The aims of this research were to study and compare the changes of physicochemical properties and antioxidant properties of different onion varieties (red, yellow, and white onions) during wine fermentation for 30 days. The result showed that fermentation rate of red onion was slower than other onions, expressed by alcohol content and pH of the wine produced. However, red onion had higher antioxidant capacities before and after fermentation than yellow and white onions from all three observed antioxidant capacities. After fermentation, there was increase in DPPH radical scavenging and Trolox equivalent antioxidant capacities in all onion varieties. In addition, anthocyanin content of red onion decreased in large amount, however, it didn’t impact the total flavonoid content.

1. Introduction
Onion (Allium cepa L.) is the second most important horticulture crop after tomato and is an important source of dietary flavonoids [1]. Its consumption is attributed to several factors, mainly heavy promotion that links flavor and health and the popularity of onion-rich ethnic foods. All varieties of onions (white, yellow or red) have many health benefits and are one of major source of various biologically active phytochemicals, including phenolic acids, flavonoids, cepaenes, thiosulfinates, and anthocyanins [2]. The red color in red onion is caused by anthocyanins consisting mainly cyaniding or peonidin glucosides [3]. Anthocyanins are also reported to be a source of antioxidant activity. However, white onions contain less flavonoid content than colored onion [4]. Since antioxidant activity of phenolic phytochemicals was enhanced in presence of alcohol [5], it could be assumed that fermented alcoholic vegetables and fruits have higher antioxidant activity than raw vegetables and fruits [6-7]. Therefore, the aim of this research was to determine and compare the psychochemical properties, antioxidant activities and phenolic compound of three onion varieties (red, white, yellow) before and after wine fermentation by Saccharomyces bayanus for 30 days.
2. Materials and Methods

2.1. Materials
Red, yellow and white onions (*Allium cepa*) were purchased from local market located near onion farm in Hengchun township, Pingtung, Taiwan. Yeast used was *Saccharomyces bayanus* C12 from Today Food Industry Co., Ltd., Taiwan. Other chemicals used were of analytical grade.

2.2. Wine Making
Onions purchased were washed and trimmed before grinding into puree. Afterwards, the puree was then filtered using cheesecloth and heated at 90°C for 4 min. Total soluble solid were adjusted to 24°Brix using sugar after the solution was cooled down to room temperature. Finally, *Saccharomyces bayanus* C12 activated by incubating for 15 min at 37°C was added into onion puree to reach 0.1% (w/w) of *Saccharomyces bayanus* C12 and fermented for 30 days at room temperature (±25°C). Sample were collected at day 1, 3, 5, 7, 14, 21, 30, filtered through 0.22 μm membrane filter and kept at -20°C freezer prior analysis.

2.3. Physicochemical properties determination
Color values were determined by Hunter Lab colorimeter and the results were expressed as L for lightness (0 = black, 100 = white), a for greenness and redness colors (−a = greenness, +a = redness), b for blueness and yellowness colors (−b = blueness, +b = yellowness). The pH value was measured using a pH meter (Denver Instrument UB-10, Colorado, USA). The total soluble solids were measured using refractometer, and the results were expressed as °Brix. The ethanol content was determined by gas chromatography according to method described by Chen et al. [8].

2.4. Antioxidant capacities determination
Antioxidant capacities measured were DPPH radical scavenging capacity, Trolox equivalent antioxidant capacity, and reducing power. For DPPH radical scavenging capacity, the method followed the procedure described by Sharma and Bhat [9]. Trolox equivalent antioxidant capacity was determined by ABTS+ as radical and trolox as positive control. The measurement was carried out following method described by van den Berg et al. [10]. Reducing power was measured using method described by Benzie and Szeto [11].

2.5. Phenolic content determination
Total phenolic contents were measured by UV-Visible spectrophotometer using Folin–Ciocalteau reagent based on the method described by Tezcan et al. [12], whereas total flavonoid contents were also determined using colorimetric method through flavonoid-aluminum chloride (AlCl₃) complexation and based on method described by Xu and Chang [13]. The content of anthocyanins was determined by the pH-differential method [14]. Each extract (0.5 mL) was diluted with 2.5 mL of 0.025 M potassium chloride buffer, pH 1.0 and 0.4 M sodium acetate buffer, pH 4.5, separately. The diluted solutions were then left at room temperature for 15 min, and the absorbance of each dilution was read at 520 and 700 nm against a blank cell filled with distilled water. The anthocyanin content (mg/100 g of dry matter) was calculated from A x MW x DF / (Ɛ x W), where A refers to absorbance (A520nm A700nm) at pH 1.0 deducted by (A520nm - A700nm) at pH 4.5, MW refers to molecular weight of cyaniding-3-glucoside, DF refers to dilution factor, Ɛ refers to molar absorptivity (26900), and W refers to sample weight (g).

3. Results and Discussion
The change of alcohol content, pH and total soluble solids (TSS) during wine fermentation of different onions is shown in figure 1. From figure 1A, the wine produced was considered good wine as it reached 12% of alcohol (ethanol) content or above. Comparing different onion varieties, wine made
from yellow and white onions reached higher ethanol content compared to wine from red onion. It might be due to higher anti-microbial activities against *Saccharomyces cerevisiae* found in the red onion compared to yellow and red onions. Kivanc and Kunduho [15] have shown anti-microbial activity of onion against *Saccharomyces cerevisiae*. In addition, Benkeblia [16] also reported that essential oils from red onion has higher antimicrobial activity compared to yellow onion.

**Figure 1.** The changes of (A) alcohol content, (B) pH value, and (C) total soluble solid during wine fermentation of different onion varieties.

Before fermentation, different onion varieties have different pH values and the pH was found to reduce during fermentation and slight reduction in pH was observed in the first three days of fermentation (figure 1B). Before fermentation, red onion showed lower pH value compared to yellow and white onions, but after fermentation, wine made from red onion had higher pH value compared to other onions. Total soluble solid (TSS) is used to predict sugar amount in solution. TSS decreased as the alcohol content increased, which represent that the sugar was consumed by yeasts for their growth. TSS of wine made from different onion varieties showed no difference as shown in figure 1C.

**Figure 2** shows the changes of color space represented by L*, a* and b* values during wine making from different onions. The lightness of all onion varieties increased after fermentation, but the highest change of solution lightness was found in red wine, while the wine with highest lightness value was made from white onion (figure 2A). The value of a* represents red in positive value and green in negative value. The redness of onion reduced during fermentation (figure 2B). Yellow and white onions, which originally tend to have greenish color, increased their reddish color during fermentation. The value of b* represents yellow in positive value and blue in negative value. The yellowness of red onion increased after fermentation (figure 2C). Anthocyanins are the compounds responsible for the color of red onion and the decrease of anthocyanins during wine fermentation has been reported in previous report [17].

**Figure 2.** The changes of color space represented by (A) L* value, (B) a* value, and (C) b* value during wine fermentation of different onion varieties.
The antioxidant properties determined as DPPH radical scavenging activity, trolox equivalent antioxidant capacity, and reducing power are shown in figure 3. In general, red onion showed the highest antioxidant capacity before and after fermentation than other onion varieties from all three observed antioxidant determinations. After fermentation, onions tended to increase in DPPH radical scavenging (figure 3A) and Trolox equivalent antioxidant capacity (figure 3B). For reducing power antioxidant capacity, red and white onions showed increase at the early stage of fermentation but these activities started to reduce from the day-5 of fermentation. The changes in antioxidant properties may be caused by the regradation and formation of compounds with anti-oxidant properties, for example phenolic compounds.

![Figure 3](image-url)

Figure 3. The changes of (A) DPPH radical scavenging activity, (B) trolox equivalent antioxidant capacity, and (C) reducing power during wine fermentation of different onion varieties.

Phenolic compounds are a group of compounds contributing to onion’s bioactivity including antioxidant capacity. Phenolic compounds are divided into phenolic acids, flavonoids, stilbenes, coumarins, lignans, and tannins [18]. Flavonoids are further divided into flavonols, flavononols, flavones, flavanols, flavanones, anthocyanidins, and isoflavonoids [18]. To study the changes of phenolic contents, total phenolic content, total flavonoid content and total anthocyanin content were determined. The results of these content are shown in Figure 4. Total phenolic content tends to increase in small amount after fermentation (figure 4A). Interestingly, although there were no big changes in flavonoid compounds (figure 4B), anthocyanin content of red onion (figure 4C) decreased in large amount.

![Figure 4](image-url)

Figure 4. The changes of (A) total phenolic content, (B) total flavonoid content, and (C) total anthocyanin content during wine fermentation from different onion varieties.
4. Conclusions
In general, alcohol content of wine made from red onion was lower than wine made from other onions, the pH value was higher than wine made from other onions, indicating that the fermentation rate of red onion is slower than other onions. There was increase in DPPH radical scavenging and Trolox equivalent antioxidant capacities in all onion varieties after fermentation. Moreover, red onion had higher antioxidant capacities before and after fermentation than yellow and white onions from all three observed antioxidant capacities. Anthocyanin content of red onion decreased in large amount, but its impact did not reflect in the flavonoid content.

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