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Alteration of antioxidative properties of longan flower-honey after high pressure, ultra-sonic and thermal processing

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ABSTRACT

This work evaluated the effect of high hydrostatic pressure (300–500 MPa/25 °C/5–20 min), ultra-sonic (20–60% amplitude/20 kHz/5–20 min) and thermal (50–100 °C/1–5 min) processing on phenolic contents and antioxidant capacities of honey from the longan flower. Total phenolic compounds, total flavonoids and antioxidant capacity (DPPH and FRAP assays) were determined. It was found that high pressure, ultra-sonic and thermal treatments had a significant effect on antioxidative properties of honey sample. After pressurization, the quantities of total phenols, flavonoids and antioxidant capacity in honey significantly increased with the increasing pressure levels and processing times, in particular samples pressurized at 500 MPa for 20 min. Similarly, these bioactive compounds in honey samples processed by ultra-sonication were also enhanced when the amplitude levels and treatment times increased. For thermal treatments at 50 and 70 °C, all antioxidative constituents had no significant differences when compared to the control, while the sample heated at 100 °C contained the lowest levels of phenols and antioxidant capacity. Therefore, both high pressure and ultra-sonic processing are an alternative technique to preserve the antioxidative qualities of longan flower-honey, while also not affecting the nutritional values.

1. Introduction

Longan flower-honey is commercially produced in both Chiang Mai and Lamphun provinces, Thailand. It is mainly used as a natural sweetener in various food products, and is composed of a concentrated aqueous solution of inverted sugars and various nutrients such as saccharides, amino acids, phenolics, flavonoids, vitamins and minerals (Akhmazillah, Farid, & Silva, 2013; Gheldof, Wang, & Engeseth, 2002; Moniruzzaman, Sulaiman, Khalil, & Gan, 2013). Bioactive constituents in honey are responsible for its health benefits. It has been reported to possess antioxidant, anti-mutagenic, antitumor, antimicrobial, antiviral, anti-parasitic and anti-inflammatory effects (Bogdanov, Jurendic, Sieber, & Gallmann, 2008; Gomez-Caravaca, Gomez-Romero, Arraez-Roman, Segua-Carretero, & Fernandez-Gutierrez, 2006; Kucuk et al., 2007). The benefits of honey consumption for

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diabetic type 2 patients have also been reported (Bahrami et al., 2009). Akhmazillah et al. (2013) and Aljadi and Kamaruddin (2004) stated that the composition and antioxidant capacity of honey depend on the floral sources, seasonal and environmental factors as well as processing methods. Liu, Ye, Lin, Wang, and Peng (2013) found that *Bidens pilosa* flower-honey showed the highest amounts of total phenols, flavonoids and antioxidant capacity (DPPH assay), followed by honeys from multiflora forest, longan flower and litchi flower, respectively. Additionally, Sangsrichan and Wanson (2008) demonstrated that honeys collected in the Northern part of Thailand produced from longan flowers had significantly higher levels of total phenols and antioxidant activities (DPPH and ABTA assays) than in wild flowers, sunflowers and litchi flowers, respectively.

In the recent years, high hydrostatic pressure has been successfully used to produce various foods with high quality. This method inactivates microorganisms in food matrices for shelf-life extension (Cao et al., 2012; Chaikham & Apichartsrangkoon, 2012a,b; Keenan, Rößle, Gormley, Butler, & Brunton, 2012). Many researchers have studied the effect of high pressure processing on the physicochemical qualities of various fruit and vegetable products, including blueberry juice (Barba, Esteve, & Frigola, 2013), strawberry juices (Cao et al., 2012), mango pulp (Kaushik, Kaur, Rao, & Mishra, 2014), carrot and spinach (Jung, Lee, Kim, & Ahn, 2013). Overall, they reported that high pressure processing could be an alternative technique to preserve the qualities of food products more effectively than thermal treatments. Besides high pressure processing, ultra-sonication is also an innovative technology, which has been shown to improve and preserve the nutritional values and sensorial qualities of fruit juices, such as purple cactus pear, apple, grape and grapefruit juices (Aadil, Zenga, Han, & Sun, 2013; Abid et al., 2013; Gabriel, 2012; Tiwari, Patras, Brunton, Cullen, & O'Donnell, 2010; Zafra-Rojas et al., 2013).

However, to date there has been little research on the effects of high pressure, ultra-sonic and thermal treatments on bioactive components and antioxidant properties present in honey. For conventional method, Kowalski (2013) found that total phenolic compounds and antioxidant activity ($ABTS^+$ assay) of honeydew honey apparently declined after processing at 90 °C up to 60 min, whereas a significant increase of these properties in lime and buckwheat honeys was observed. Therefore, the aim of this work was to determine the changes of antioxidative properties in pressure, ultra-sonic and thermal treated longan flower-honeys as compared to untreated honey. Moreover, the storage stability of all treated honeys was also evaluated.

2. Materials and methods

2.1. High pressure processing

Longan flower-honey was freshly harvested from bee farms in Lamphun province, Thailand. Briefly, 100 mL of honey were packed in a laminated bag (nylon plus polyethylene; Siampack, Bangkok, Thailand) and subjected to pressure levels of 300, 400 or 500 MPa at 25 °C for 5–20 min. The high pressure vessel was a 'Food Lab' model 900 high pressure rig (Stansted Fluid Power, Stansted, UK). The pressure transmitting medium used in this experiment was a mixture of 98% ethanol and castor oil (Chemical & Lab Supplies, Bangkok, Thailand) at a ratio of 80:20 (v/v).

2.2. Ultra-sonic processing

A 100-mL of honey in a 150-mL glass bottle was treated using a high intensity ultra-sonic processor (VCX 130 PB 130 W, Sonics & Materials Inc., Newtown, CT). The ultra-sonic probe was inserted into the honey to half the depth of the sample which produced a 20 kHz wave. The honey was exposed at different amplitude levels of 20%, 40% and 50% for 5, 10, 15 and 20 min.

2.3. Thermal treatment

A 100-mL of honey was filled into a retort pouch (Siampack, Bangkok, Thailand). Consequently, the honeys packed in the pouches were immersed in a thermostatic water bath and heated until the inside temperatures reached 50 ± 2, 70 ± 2 or 100 ± 2 °C, continuing to hold the temperature for 1, 3 or 5 min. Afterward, all treated samples were immediately placed in cooled water for 10 min before analysis.

2.4. Determination of total phenolic compounds

Total phenolic compounds were determined using the Folin–Ciocalteu reagent following the modified method of Chaikham and Apichartsrangkoon (2012a). Two grams of honey were mixed with 2 mL deionized water and then transferred into 8 mL of cooled absolute ethanol (Chemical & Lab Supplies, Bangkok, Thailand). After stirring for 15 min, the mixture was centrifuged at 3000 rpm for 10 min. A 0.5-mL of supernatant was mixed with 2.5 mL of 10% Folin–Ciocalteu reagent (Sigma, Munich, Germany) and allowed to react for 5 min. Afterward, 2 mL saturated sodium carbonate solution (Ajax, Sydney, Australia) was added to the mixture and held for 2 h at room temperature. The apparent blue complex was determined using a spectrophotometer at a λ_{max} 765 nm (Perkin Elmer UV WINLAB; Perkin Elmer, Waltham, MA). Total phenolic compounds were expressed as mg gallic acid equivalent per 100 g sample (mg GAE/100 g).

2.5. Determination of total flavonoids

Total flavonoids were determined following the method of Šarić et al. (2012) with some modifications. One gram honey was added into 2 mL deionized water containing 0.9 mL $NaNO_2$ (Sigma-Aldrich, St. Louis, MO). After mixing for 5 min, 0.9 mL of 10% (w/v) $AlCl_3$ (Sigma-Aldrich, St. Louis, MO) was transferred into the mixture, stirred for 6 min before 6 mL of 1 M NaOH (Ajax, Sydney, Australia), were added. The solution was shaken and measured at a λ_{max} 510 nm. Total flavonoids were expressed as mg quercetin equivalent per 100 g sample (mg QE/100 g).