

SCREENING ON ANTIOXIDANT ACTIVITIES OF BY – PRODUCTS FROM VEGETABLES AND FRUITS IN VIET NAM AND APPLYING FOR SHRIMP COLD STORAGE

SÀNG LỘC HOẠT TÍNH CHỐNG OXY HÓA CỦA CÁC PHỤ PHẨM TỪ RAU CỦ VIỆT NAM VÀ ỨNG DỤNG TRONG BẢO QUẢN LẠNH TÔM THẺ CHÂN TRẮNG (*LITOPENAEUS VANNAMEI*)

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ABSTRACT

We have carried out studying for antioxidant activity of 58 extracts prepared from vegetables and fruits in Viet Nam by three methods including DPPH and H_2O_2 scavenging activity assays and determination of total flavonoid content (TFC). Ethanol extract of Tamarind seed (NTBT-17), Grape seed (NTBT-19) and Mangosteen peel (TNB-10) showed high amount of TFC which is 848.8, 655.9 and 422.9 mgQE/100g, respectively. In addition, NTBT-17, NTBT-19 and mango seed (TNB-11) exhibited strong activity with the following IC_{50} (DPPH method) values: 6.91, 2.10, 1.84 $\mu\text{g/mL}$, respectively. Basing on the H_2O_2 assay, TNB-10 has the lowest IC_{50} value of 104.2 $\mu\text{g/mL}$. Therefore, TNB-10 extract was used as a natural antioxidant food preservative for white shrimp (*Litopenaeus vannamei*) cold storage at 2°C and tested sensory evaluation of melanosis development and lipid peroxidation inhibition assay (TBARs). Shrimps treated by TNB-10 had gray values and TBARs values lower than the control samples (treated by water) and shrimps treated by sodium metabisulfite (SMS). According to the identification of constituents in TNB-10 by HPLC-ESI-MS, nine antioxidant compounds namely, α -mangostin, β -mangostin, γ -mangostin, 8-dexoxygartanin, garcinone B, garcinone C, garcinone D, 9-hydroxycalabaxanthone, and garcinmangosone C were found. These results suggested that mangosteen peel extract was able to slow down oxidation process of fat and melanosis development in white shrimp during the cold processing.

Keywords: Antioxidant activity; TBARs; by-product; Mangosteen peel; *Litopenaeus vannamei*.

TÓM TẮT

Hoạt tính chống oxy hóa của 58 mẫu cao chiết ethanol điều chế từ các phụ phẩm rau quả Việt Nam được thử nghiệm trên các mô hình ức chế gốc tự do DPPH, H_2O_2 và xác định tổng hàm lượng flavonoid. Các mẫu cao ethanol của hạt me (NTBT-17), hạt nho (NTBT-19) và vỏ măng cụt (TNB-10) thể hiện hoạt tính mạnh với tổng hàm lượng flavonoid lần lượt là 848,8; 655,9 và 422,9 mgQE/100g mẫu khô. Trên mô hình ức chế gốc tự do DPPH, các mẫu NTBT-17, NTBT-19 và hạt xoài (TNB-11) thể hiện hoạt tính mạnh với các giá trị IC_{50} là 6,91; 2,10; 1,84 $\mu\text{g/mL}$. Giá trị IC_{50} của mẫu vỏ măng cụt (TNB-10) thấp nhất trên mô hình ức chế H_2O_2 là 104,2 $\mu\text{g/mL}$. Do đó, mẫu TNB-10 được chọn để thử nghiệm bảo quản lạnh tôm thẻ chân trắng (*Litopenaeus vannamei*) tại 2°C trong 7 ngày và được đánh giá bằng phương pháp cảm quan điểm biến đen và quá trình ức chế peroxide hóa lipid. Các mẫu tôm được xử lý bằng TNB-10 có điểm biến đen và giá trị TBARs thấp hơn mẫu tôm ngâm bằng nước cất (mẫu chứng) và mẫu tôm xử lý bằng phụ gia thương mại sodium metabisulfite (SMS). Phân tích thành phần hóa học của TNB-10 bằng phương pháp HPLC-EIS-MS, định danh được 9 hợp chất chống oxy hóa là α -mangostin, β -mangostin, γ -mangostin, 8-dexoxygartanin, garcinone B, garcinone C, garcinone D, 9-hydroxycalabaxanthone, and garcinmangosone C. Kết quả nghiên cứu cho thấy

tiềm năng sử dụng vỏ măng cụt trong việc hạn chế sự hình thành biến đen và oxy hóa lipid ở tôm trong quá trình bảo quản lạnh.

Từ khóa: Hoạt tính chống oxy hóa; TBARs; phụ phẩm; vỏ măng cụt; *Litopenaeus vannamei*.

1. INTRODUCTION

In recent years, shrimp and shrimp products have occupied a large portion in the exported seafood products of Vietnam [1]. However, they are among the most perishable commodities, and their spoilage begins soon after the death after catching. Discoloration and oxidation in shrimp are serious problems affecting organoleptic, nutritional and economic value of shrimp after harvesting. Improper handling could hasten spoilage, resulting in gradual development of undesirable qualities in seafood products. Thus, effective handling and preservation techniques need to be used to address the problems of postharvest losses [2]. The addition of antioxidants to products is one of the most widely studied methods for controlling discoloration and lipid oxidation in shrimp. Antioxidants have many modes of action which include sequestering catalytic metal ions, decreasing oxygen concentration, quenching single oxygen and superoxide anion, decomposing primary oxidation products to non-volatile compounds, preventing first-chain initiation by scavenging initially generated radicals and chain breaking [2].

In Vietnam, a large amount of by-product derived from vegetables and fruits are generated in the food industry, merely a part of it has been used as a fertilizer. Therefore, we selected 58 by-products from vegetables and fruits for screening on their antioxidant activities. The selected vegetables and fruits were collected from Tay Nguyen area (TN), Ninh Thuan – Binh Thuan provinces (NTBT) and the Mekong delta (TNB). The selected by-product extract with the highest antioxidant activity is then used to preserve shrimp for preventing melanosis development and lipid peroxidation and analyzed by HPLC method for its chemical contents.

2. EXPERIMENTAL

2.1. Plant materials

By-product samples were collected across Viet Nam and purchased in markets or supermarkets. They were chosen based on two criteria for dissemination and easy collection. After that, samples were identified, preserved and stored in biochemistry lab, and are signed (number sample on table 1). White shrimps (*Litopenaeus vannamei*) with the size of 30-40 shrimps/kg were purchased from Thu Duc market, kept alive and transported to the laboratory at HCMUTE.

2.2. Chemicals

2,2 – Diphenyl – 1 – picrylhydrazyl (DPPH), Malonaldehyde (MDA), sodium nitrite (NaNO_2), and Vitamin C were purchased from Merck (Darmstadt, Germany). Trichloroacetic acid (TCA), thiobarbituric acid (TBA), gallic acid, quercetin and hydrogen peroxide 3% (H_2O_2) were purchased from Sigma Chemical Co. (U.S.A.). Other chemicals were purchased from China.

2.3. Screening on antioxidant activities

2.3.1. Preparation of samples

Samples (50-100g) were cleaned with water, air-dried, cut into small pieces and extracted with ethanol solvent (200 – 350 mL, reflux, 3h \times 3, 60-70°C). Then, the extract solutions were evaporated under reduced pressure in order to dry and recover the extracts.

2.3.2. DPPH free radical scavenging assay

The stable DPPH free radical was used for determining free radical-scavenging activity of the extracts [3]. Briefly, a 0.1 mM solution of DPPH in 90% ethanol was prepared and then 1.5 mL of this solution was mixed with 1.5 mL of each sample

(crude extract) at concentrations of 100, 50, 25, 10 $\mu\text{g}/\text{mL}$ in 90% ethanol. After 30 mins incubation in the dark, the decrease in the solution absorbance was measured at 517 nm using Hitachi UH-530 spectrophotometer. DPPH inhibitory activity was expressed as the percentage inhibition (I%) of DPPH in the above assay system, calculated as $(1-B/A)\times 100$, where A and B are the activities of the DPPH without and with test material. IC_{50} (inhibitory concentration, 50%) values were calculated from the mean values of data from three determinations. Gallic acid at various concentrations (1, 2.5, 5, and 10 μM) was used as a positive control.

2.3.3. Hydrogen peroxide scavenging assay

Hydrogen peroxide itself is not very reactive, but it can sometimes be toxic to cell because it may give rise to hydroxyl radical in the cells. The ability of the ethanol extracts to scavenge hydrogen peroxide was determined according to the method of Ruchet [4]. A solution of hydrogen peroxide (1500 μL) was prepared in phosphate buffer (pH 7.4). Extracts at concentrations of 2000, 1000, 500, 250, and 100 $\mu\text{g}/\text{mL}$ in distilled water were added to a hydrogen peroxide solution. Absorbance of hydrogen peroxide at 220 nm was determined 10 minutes later against a blank solution containing the phosphate buffer without hydrogen peroxide. H_2O_2 inhibitory activity and IC_{50} values were calculated the same as DPPH free radical scavenging assay. Vitamin C at various concentrations (200, 100, 50, 25 μM) was used as a positive control.

2.3.4. Determination of flavonoid content

The total flavonoid content of ethanol was determined using the aluminum chloride assay through colorimetry [5]. Aliquots of extract solution (1 mg) were taken in 10 ml glass tube and made up to the volume 5 mL with ethanol. Later, 150 μL AlCl_3 (10%), 150 μL NaNO_2 (5%), 1000 μL NaOH (4%) and 1200 μL distilled water were added sequentially. After 30 min of incubation the mixture turns to pink whose absorbance was

measured at 550 nm using the spectrophotometer. The contents of flavonoids in the samples were calculated from the calibration plot and expressed as mg quercetin equivalent per 100 gram of extract (mgQE/100g). All the determinations were carried out three times.

2.4. Applying for shrimp cold storage

2.4.1 Shrimp treatment

Shrimps were immersed in selected extract solutions prepared in a weight ratio of 1:15 (extract/water), water and 1.25% SMS. After 3-5 minutes at room temperature, shrimps were drained off, packed separately in plastic boxes and preserved at 2°C. Shrimps from each treatment were taken every 3 days up to 7 days for evaluation of melanosis development and lipid peroxidation.

2.4.2. Sensory evaluation of melanosis development

Ten candidates (19-22 years old) for panelists were selected from students of the Chemical and Food Technology Faculty, HCMUTE on the basis of both availability and knowledge in organoleptic test. Panelists were trained three times in descriptive analysis of flavor, color and aroma properties of shrimp before testing. The gray value in shrimp was evaluated directly and classified according to the degree of black spot formation using modified Montero's sensory evaluation [6]. Ten candidates evaluated gray values in shrimp by levels 1 to 5 scale as follow: point 0 = no point; point 1 = light (about 20% of the surface area affected shrimp); point 2 = the average (20-40% surface area); point 3 = significant (40-60% surface); point 4 = very severe (60-80% surface); point 5 = very terrible / not acceptable (80-100% surface area).

2.4.3. Lipid peroxidation inhibition assay (TBARs)

Oxidation of fat in shrimp is a serious problem that reduces the organoleptic, nutritional and economic value of the shrimp

harvest. MDA is considered to be the final product of the oxidation process of lipid peroxidation. TBA reacts with MDA to form a di-adduct, a red chromogen, which can be detected at 532 nm [7]. Treated shrimps were grinded by machine, mixed thoroughly with 10 mL of TCA 7.5% solution. After filtering, the filtrate was mixed with TBA 0.02M with equal volume rate. Then, the mixture was heated at 100°C for 15 min and cooled down. Absorbance was measured at 532 nm using Hitachi UH530. MDA contents were calculated from standard curve built at concentrations from 0.01 to 0.05 μM and reported as mgMAD/kg shrimp. MDA content values were calculated from the mean values of data from three determinations.

2.5. HPLC-EIS-MS analysis of TNB-10

RP-HPLC was performed to determination chemical constituents of Mangosteen peel extract. The separation module consisted of Agilent 1200 series HPLC (USA) equipped with ESI-MS system (microTOF-QII Bruker Daltonic, Germany). The samples was eluted on a column ACE3-C18 (4.6 \times 150 mm, 3.5 μm , Merck, Germany) with a gradient system consisting of solvent A (0.1% formic acid in water) and solvent B (0.1% formic acid in methanol) used as the mobile phase, with a flow rate of 0.5 mL/min. The temperature of the column was maintained at 40°C and the injection volume 20 μL . For ESI-MS, full scan mass spectra were measured between m/z 150 and 2000. High purity nitrogen was used as nebulizer gas at 1.2 bar, 200°C and at a flow rate of 0.8 mL/min.

3. RESULTS AND DISCUSSION

3.1. Screening on antioxidant activities

In a series of the following *in vitro* tests including determination of total flavonoid content, DPPH free radical scavenging assay and hydrogen peroxide radical scavenging assay, antioxidant activity of extracts from Viet Nam plant by-products was compared to gallic acid and vitamin C as positive control samples.

3.1.1. Total flavonoid contents

The total flavonoid contents of 58 ethanol extracts were determined in accordance with the equation $y = 231.43x + 3.6485$ ($r^2 = 0.9914$) and TFC values were shown in Table 1. TFC values (mgQE/100g) of three samples having strong activities were arranged in a decreasing order: Tamarind seed (**NTBT-17**, 848.8) > Grape seed (**NTBT-19**, 655.9) > Mangosteen seel (**TNB-10**, 422.9).

3.1.2. DPPH free radical scavenging assay

The results by this assay were showed briefly in Table 1. In total, 21 ethanol extracts showed IC_{50} values below 100 $\mu\text{g/mL}$, 15 extracts with IC_{50} values less than 50 $\mu\text{g/mL}$, 11 extracts exhibited IC_{50} values below 25 $\mu\text{g/mL}$, and 6 extracts with IC_{50} values below 10 $\mu\text{g/mL}$. IC_{50} value of gallic acid was 8.7 μM (2.2 $\mu\text{g/mL}$). The DPPH scavenging activity of the six ethanol extracts in decreasing order was: Mango seed (**TNB-11**, 1.84 $\mu\text{g/mL}$) > Grape seed (**NTBT-19**, 2.10 $\mu\text{g/mL}$) > Tea stem (**TN-9**, 6.61 $\mu\text{g/mL}$) > Passion-fruit seed (**TN-16**, 6.73 $\mu\text{g/mL}$), Tamarind Seed (**NTBT-17**, 6.91 $\mu\text{g/mL}$) > Mangosteen peel (**TNB-10**, 8.38 $\mu\text{g/mL}$). The effect of antioxidants on DPPH radical scavenging is thought owing to their hydrogen donating ability. On analyzing the results obtained in DPPH assay, it was noticed that extracts act as good hydrogen donating agent, there by bleaches the DPPH or reduces its absorbance.

3.1.3. Hydrogen peroxide radical scavenging assay

The scavenging ability of the extracts based on hydrogen peroxide assay is shown in Table 1. According to the IC_{50} results, the scavenging activity values on hydrogen peroxide of the extracts were arranged according to this order: Mangosteen peel (**TNB-10**, 104.2 $\mu\text{g/mL}$) > Grape seed (**NTBT-19**, 105.9 $\mu\text{g/mL}$) > Tamarind seed (**NTBT-17**, 113.8 $\mu\text{g/mL}$). The remaining extracts have higher IC_{50} value which show low antioxidant activity. IC_{50} value of vitamin C was 219.7 μM (54.8 $\mu\text{g/mL}$).

Table 1. The list of 58 vegetables and fruits in Viet Nam and their IC₅₀ values of 58 extracts using DPPH assay and H₂O₂ assay and the total flavonoid content. [7]

No.	Sign	Scientific name	Family	Part Used	IC ₅₀ (µg/mL)		TFC (mgQE/100g)
					DPPH	H ₂ O ₂	
1	TN- 1	<i>Annonamuricata</i>	Annonaceae	Peel	> 100	1422.0	118.2
2	TN- 2			Seed	53.6	-	-
3	TN- 3	<i>Artocarpusheterophyllus</i> Lam.	Moraceae	Peel	>100	>2000	109.0
4	TN- 4	<i>Anacardiumoccidentale</i> L.	Bixaceae	Peel	32.1	>200	142.1
5	TN- 5	<i>Brassica oleracea</i> Gongylodes Group	Brassicaceae	Peel	>100	1837.8	85.0
6	TN- 6	<i>Brassica oleracea</i> L. var. capitata L. f. rubra		Peel	>100	-	112.0
7	TN- 7	<i>Brassica oleracea</i> var. italica		Stem	>100	>2000	128.2
8	TN- 8	<i>Brassica oleracea</i> var. botrytis		Stem	>100	>2000	73.5
9	TN- 9	<i>Camellia sinensis</i>	Theaceae	Stem	6.61	-	-
10	TN- 10	<i>Coffeacaneophora</i>	Rubiaceae	Peel	83.3	>200	288.7
11	TN- 11	<i>Cucurbita maxima</i>	Cucurbitaceae	Peel	>100	>2000	114.4
12	TN- 12	<i>Momordicacochinchinensis</i>		Peel	>100	>2000	95.8
13	TN- 13			Seed	>100	-	-
14	TN- 14	<i>Morus alba</i>	Moraceae	Leaf	>100	>2000	235.5
15	TN- 15	<i>Passifloraedulis</i>	Passifloraceae	Peel	88.2	>200	151.3
16	TN- 16			Seed	6.73	-	-
17	TN- 17	<i>Pisum sativum</i>	Fabaceae	Peel	>100	-	91.7
18	TN- 18	<i>Solanumtuberosum</i> (L.)	Solanaceae	Peel	15.7	133.7	275.6
19	NTBT-1	<i>Annona squamosa</i>	Annonaceae	Peel	24.5	165.4	151.4
20	NTBT-2			Seed	>100	-	-
21	NTBT-3	<i>Artocarpus heterophyllus</i>	Moraceae	Peel	>100	>2000	161.4
22	NTBT-4			Seed	>100	1692.1	126.7
23	NTBT-5	<i>Carica papaya</i>	Caricaceae	Peel	>100	>2000	114.4
24	NTBT-6			Seed	>100	-	-
25	NTBT-7	<i>Citrullus lanatus</i>	Cucurbitaceae	Peel	>100	>2000	112.0
26	NTBT-8			Seed	>100	-	-
27	NTBT-9	<i>Chrysophyllum cainino</i>	Sapotaceae	Peel	>100	-	-
28	NTBT-10			Seed	>100	-	-
29	NTBT-11	<i>Hylocereus undatus</i>	Cactaceae	Peel	>100	-	-
30	NTBT-12	<i>Lucuma obovata</i>	Sapotaceae	Seed	>100	-	-
31	NTBT-13	<i>Passiflora incarnata</i>	Passifloraceae	Peel	>100	>2000	235.5
32	NTBT-14			Seed	12.7	118.4	148.3
33	NTBT-15	<i>Phyllanthus acidus</i>	Phyllanthoideae	Seed	>100	-	-
34	NTBT-16	<i>Tamarindus indica</i>	Fabaceae	Peel	20.1	160.8	271.0
35	NTBT-17			Seed	6.91	113.8	848.8
36	NTBT-18	<i>Vitis vinifera</i>	Vitacea	Peel	>100	>2000	45.7
37	NTBT-19			Seed	2.10	105.9	655.9
38	NTBT-20	<i>Ziziphus mauritiana</i>	Rhamnaceae	Seed	>100	>2000	131.3
39	TNB- 1	<i>Ananas comosus</i>	Bromeliaceae	Stem	>100	-	243.2
40	TNB- 2	<i>Bacopa monnieri</i>	Scrofulariacea	Stem	43.2	181.1	265.6
41	TNB- 3	<i>Chrysophyllum cainino</i>	Sapotaceae	Peel	>100	-	-
42	TNB- 4			Seed	>100	-	-
43	TNB- 5	<i>Citrus maxima</i>	Rutaceae	Peel	>100	>2000	90.4
44	TNB- 6			Seed	>100	-	-

45	TNB- 7	<i>Citrus reticulata</i>	Rutaceae	Peel	87.3	>200	321.9
46	TNB- 8			Seed	>100	-	-
47	TNB- 9	<i>Dimocarpus longan</i>	Sapindaceae	Seed	79.3	189.1	122.1
48	TNB- 10	<i>Garcinia mangostana</i>	Clusiaceae	Peel	8.38	104.2	422.9
49	TNB- 11	<i>Mangifera indica L.</i>	Anacardiaceae	Seed	1.84	121.3	192.3
50	TNB- 12	<i>Manilkara zapota</i>	Sapotaceae	Peel	>100	905.3	112.0
51	TNB- 13			Seed	>100	-	-
52	TNB- 14	<i>Momordica cochinchinensis</i>	Cucurbitaceae	Peel	44.3	1991.5	90.4
53	TNB- 15			Seed	>100	>2000	86.6
54	TNB- 16	<i>Musa acuminata</i>	Musaceae	Peel	>100	>2000	139.8
55	TNB- 17			Seed	13.5	126.0	203.1
56	TNB- 18	<i>Neptunia oleracea</i>	Fabaceae	Whole plant	>100	1892.2	196.1
57	TNB- 19	<i>Solanum andigenum</i>	Convolvulaceae	Peel	27.1	176.1	325.0
58	TNB- 20	<i>Spondias dulcis</i>	Anacardiaceae	Peel	70.8	-	182.2

Based on the results obtained from the determination of flavonoid, DPPH and H₂O₂ assay, ethanol extract from Mangosteen peel was used as natural antioxidant food preservatives for shrimp cold storage at 2°C. For further investigation, constituent compounds of **TNB-10** were analyzed by HPLC-EIS -MS.

3.2. Applying for shrimp cold storage

3.2.1. Melanosis evaluation

In general, gray values occur significantly after 3 days of preservation. Treated shrimp samples by **TNB-10** have gray values lower than the control sample in cold storage (Fig. 1, 2).

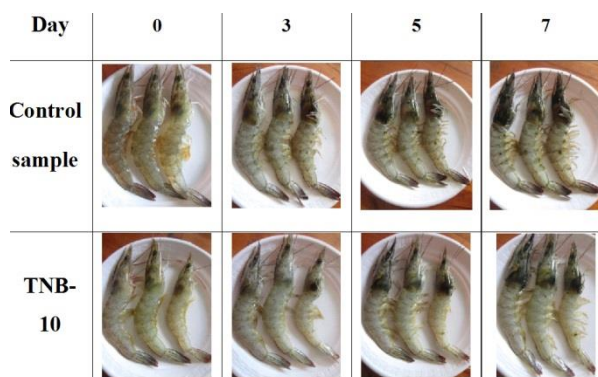


Fig 1. Development of melanosis in shrimps at 2°C

Gray values of the control sample after 3, 5, and 7 days were 3.5, 4.2, and 4.8, respectively. Meanwhile, gray values of treated shrimp samples by **TNB-10** were 2.8,

3.7, and 4.2, respectively. These results suggested that **TNB-10** is able to prevent melanosis development in shrimp during the cold processing.

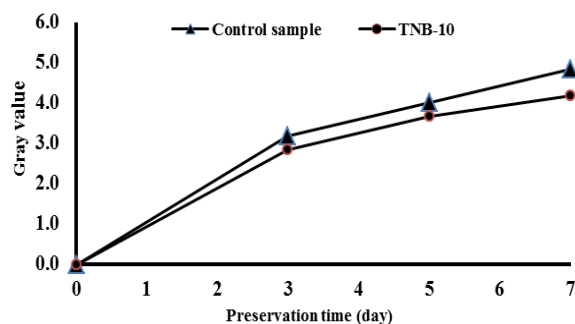


Fig 2. Changes gray values in shrimps at 2°C.

3.2.2 Lipid peroxidation inhibition assay

According to Fig 3, antioxidant activities of plant extracts on shrimps were relatively different between samples. The TBARS values of samples increased from first day to fifth day and then significantly decreased within the next two days during storage at 2°C. **TNB-10** sample had have TBARS values lower ($p < 0.05$) than the control and SMS samples. TBARS values of control sample after 3, 5, 7 days were 2.02, 2.96 and 2.74 mgMAD/kg, respectively. Meanwhile, TBARS values of **TNB-10** sample, SMS sample were 3.1, 3.8, 5.2 mgMAD/kg and 3.6, 4.5, 4.6 mgMAD/kg, respectively. The increasing TBARS values (0-5 days) is as fat oxidation powerful place in the first stage, the product of the fat oxidation such as

hydroperoxide that formatted and oxidized rapid into secondary products like aldehyde. The secondary oxidation products continue to be converted to all other products under the effect of enzymes and microorganisms, leading to diminished TBARs value (5-7 days) [8]. These results showed that **TNB-10** able to slow the process oxidation of fat in shrimp during the cold processing.

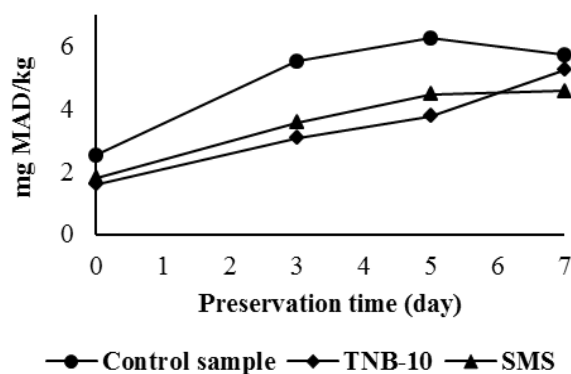


Fig3. The TBARs value change of shrimp during preservation at 2°C

3.3. Chemical Constituents of TNB-10

Table 2. Identification of 9 compounds by HPLC-MS

No	Compounds	[M-H] ⁻ (m/z)	Predicted formula
1	α -mangostin	409.16565	C ₂₄ H ₂₆ O ₆
2	β -mangostin	423.180215	C ₂₅ H ₂₈ O ₆
3	γ -mangostin	395.148915	C ₂₃ H ₂₄ O ₆
4	8-dexoxygartanin	379.154000	C ₂₃ H ₂₄ O ₅
5	Garcinone B	393.133265	C ₂₃ H ₂₂ O ₆
6	Garcinone C	413.159480	C ₂₃ H ₂₆ O ₇
7	Garcinone D	427.175130	C ₂₄ H ₂₈ O ₇
8	9-hydroxycalabaxanthone	407.148915	C ₂₄ H ₂₄ O ₆
9	Garcinmangosone C	411.143830	C ₂₃ H ₂₄ O ₇

Nine xanthenes compounds namely, α -mangostin, β -mangostin, γ -mangostin, 8-dexoxygartanin, garcinone B, garcinone C, garcinone D, 9-hydroxycalabaxanthone, and garcinmangosone C were found (Table 2). According to Jung *et al.*, α -mangostin and γ -mangostin are xanthenes having strong antioxidant using the authentic ONOO⁻ and SIN-1-derived ONOO⁻ methods [9]. Additions, these compounds were present at high content in the dried mangosteen peel [10]. Thus, the presence of xanthenes may play an essential role in its antioxidant activity.

4. CONCLUSIONS

In conclusion, we have carried out a systematic investigation of antioxidant activity of 58 by-product extracts from vegetables and fruits in Viet Nam using the methods of determination of flavonoid contents, DPPH and H₂O₂ inhibitory activity assay. The results showed that many by-product extracts had strong antioxidant activities, especially the extract prepared from Mangosteen peel was chosen and applied in preserving shrimp at 2°C. The mangosteen peel extract (**TNB-10**) is better in slowing down rancidity and melanosis development in shrimp during the cold storage as compared to SMS. In addition, the results indicate a number of vegetable and fruit by-products that may be useful for the treatment of diseases relating free radical damages, and provide the basis for further research on these medicinal plant species to isolate active constituents and drug development.

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