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Utilization of the Fine Particles Obtained from Cold Pressed Vegetable Oils: A Case Study in Organic Rice Bran, Sunflower and Sesame Oils

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Abstract: Fine particles obtained from the physical refining of organic cold pressed vegetable oils which are normally discarded as a process waste can be utilized as cosmetic and food ingredients. This paper demonstrated the use of the fine particles from rice bran (Thai Jasmine and Riceberry varieties), sunflower and sesame oils as the ingredient in body mask and as dietary fiber. It was found that the fine particles from rice brans exhibited better antioxidant properties than those of sunflower and sesame. The mixed fine particles were added to body mask formula. The addition of the fine particles affected the physical properties and stability of the body mask especially viscosity and pH. Total dietary fiber recovered from the fine particles ranged from 17.91–23.83 g/100g dry sample. Dietary fiber from Riceberry exhibited the best antioxidant properties as evidenced by DPPH radical scavenging activity and reducing power.

Key words: crude oil, fine particle, fiber, physicochemical property, antioxidant property

1 Introduction

With increasing demand for natural and minimally processed foods, cold pressed vegetable oils have become more popular in the niche market. They are usually produced by small-scale manufacturers using a single screw compression press for oil extraction. The process is less capital intensive and requires no sophisticated machine. However, the production yield is low and the crude oils produced by the cold press method contain a high amount of impurities. The advantages of cold pressed vegetable oils over the industrial refined vegetable oils are their nutritional qualities and high level of physiological active compounds[1)].

Crude oils being extracted physically from the screw compression machine are subject to physical refining processes. Usually, the first step is to remove the fine particles using several techniques such as filter pressed machine, sedimentation or centrifugation. Depending on the facilities, the fine particles obtained from this step may be about 2-5%[2)]. The fine particles isolated from cold pressed vegetable oils are normally discarded as a process waste. With regards to the clean and green industry process, they could still be used for other purposes. The texture of fine particles is very smooth as they still contain some crude oils. They can be used as cosmetic ingredients. The oils extracted from several plant species are popularly included as ingredients in cosmetic products due to their high fatty acid composition[3)]. In addition, when the oil is removed, the remaining residues could be used as a source of fiber ingredients. Their components should also contain a high amount of physiological active compounds as they have not been exposed to extreme heat or chemicals.

Fiber ingredients from natural sources are highly demanded in the food industry. Numerous studies have demonstrated the beneficial effects of fiber consumption in protection against heart disease and cancer, normalization of blood lipids, regulation of glucose absorption and insulin secretion and prevention of constipation and diverticular disease[4–7)].

Therefore, this study aimed to evaluate the physicochemical and functional properties of the fine particles extracted from the organic cold pressed vegetable oils (rice bran oils from Thai Jasmine rice and Riceberry, sunflower and sesame oils). The utilization cases in this paper are divided into both non-food (cosmetic product) and food (dietary fiber) applications.

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2 Materials and Methods

2.1 Samples preparation

Fine particles which are the process waste from the physical refining of organic cold pressed vegetable oils were obtained from Fa Din Pratansup (2546) Co., Ltd. (Thailand). They are the leftover residues after filtration of the crude oils. Four samples included: (1) rice bran oils (Thai Jasmine), (2) rice bran oils (Riceberry), (3) sunflower oils and (4) sesame oils. Riceberry is a newly developed Thai colored (black) rice variety, with the aim of providing optimum nutritional benefits. For utilization in a cosmetic product, the fine particles (all four samples) were mixed equally by weight. For utilization as fiber ingredient, the fine particles were defatted using the Soxhlet apparatus with hexane as a solvent. The dried-defatted fine particles were kept in a sealed container in a desiccator until further analysis. Proximate analysis of the defatted samples revealed that the samples were virtually free from fat while they contained about 12-14 g/100 g dry sample of protein and 11-22 g/100 g dry sample of ash. The protein and ash contents were used to correct dietary fiber content in fiber analysis.

2.2 Antioxidant properties of the fine particles

Ten grams of the fine particle samples were extracted with 100 mL of methanol at room temperature for 3 h under gentle stirring, followed by filtering through Whatman No.1 filter paper. The residue was re-extracted twice. Antioxidant properties were expressed as total phenolic compounds, DPPH radical scavenging activity and the inhibition on linoleic acid peroxidation[8].

The total phenolic content of the extract was measured with the Folin–Ciocalteau method, using gallic acid as a standard. A 0.1 mL of the extract solution was sampled into 2 mL of 2% Na_2CO_3 and mixed for 3 min. After adding 0.1 mL of 50% Folin–Ciocalteau reagent, the final mixture was left for 30 min before reading the absorbance at 750 nm using a spectrophotometer.

For DPPH radical scavenging activity, a portion (0.1 mL) of the extract solution in a test tube was well mixed with 3.9 mL of methanol and 1.0 mL of DPPH solution (1.0 mM in methanol). The mixture was kept at ambient temperature for 30 min prior to measurement of the absorbance at 517 nm (A_{sample} and $A_{control}$) using a spectrophotometer. BHA was used as the reference. The scavenging effect was derived from Eq. (1):

$$\text{DPPH scavenging effect}(\%) = \left[1 - \frac{A_{sample}}{A_{control}}\right] \times 100 \quad (1)$$

For inhibition on linoleic acid peroxidation, sample (0.5 mg) dissolved in 0.5 mL of DMSO was mixed with linoleic acid emulsion (2.5 mL, 0.02 M, pH 7.0) and phosphate buffer (2.0 mL, 0.2 M, pH 7.0) in a test tube. The mixed solution was then incubated at 37℃ for 72 h for completing color development rising from $FeCl_2$–thiocyanate interaction. The absorbance at 500 nm (A_{sample} and $A_{control}$) of the resultant solution was then measured by a spectrophotometer. BHA was examined for reference. The percentage of linoleic acid peroxidation inhibition was derived from Eq. (2):

$$\text{Inhibition of linoleic acid peroxidation}(\%) = \left[1 - \frac{A_{sample}}{A_{control}}\right] \times 100 \quad (2)$$

2.3 Utilization as cosmetic product (body mask)

The fine particles from all four samples were mixed equally (1:1:1:1 by weight) and used as the ingredient in body mask (high viscosity or paste mask) at 1, 3, 5 and 7 g/100 g following the formula in Table 1. The water part of the formula was adjusted according to the fine particle contents. Phase B and C were heated in water bath to 70℃, then slowly poured phase B into phase C under continuous stirring until the temperature decreased to about 40-45℃. Phases A and D were added and stirred until the mixture (body mask) temperature reached room temperature. Quality characteristics were determined including appearance, texture, color, pH, viscosity and accelerated sta-

Table 1 The formula of the body mask.

Phase	Ingredients	Content (g/100 g)
A	Kaolin light	36
	Titanium dioxide	3
B (Oil phase)	Stearic acid	3
	Dimethicone 350	1
	Aracel 165	2
	Fine particles from vegetable oils (mixture)	1, 3, 5 and 7
C (Water phase)	Water	43.5, 41.5, 39.5 and 37.5
	Glycerin	10
	Sodium lauryl ether sulfate	0.2
D	Microcare PHC	0.3

bility[9].

2.4 Utilization as food ingredient (dietary fiber)

After defatting, insoluble, soluble and total dietary fibers were determined by the AOAC enzymatic-gravimetric method using the total dietary fiber assay kit (K-TDFR, Megazyme, Ireland). Proximate analysis values (protein and ash content) obtained from the standard AOAC methods were used for fiber content corrections. Briefly, the defatted samples were treated with heat stable α-amylase at 100℃ for 1 h and then digested with protease (60℃, 1 h), followed by incubation with amyloglucosidase (60℃, 1 h) to remove protein and starch. Four volumes of 95% ethanol (preheated to 60℃) were then added to precipitate soluble dietary fiber. Precipitation was allowed to form at room temperature for 60 min, followed by filtration. The residue was then washed with 78% ethanol, 95% ethanol and acetone. The residue was then oven-dried (105℃) overnight in an oven and then weighed. Values obtained by the enzymatic method were then corrected by protein and ash contents which were determined using Kjeldahl method and ashing at 525℃ respectively.

2.4.1 Physical and morphological properties

The color was determined using a color meter (Minolta, CR-10, Japan) in CIE L*a*b* system.

Bulk density (ρb) expressed as g/mL were determined according to the method described elsewhere[10].

Water holding capacity (WHC), water binding capacity (WBC) and swelling capacity (SC) were determined according to the methods described earlier[11] with some modifications. The first step for WHC, WBC and SC was sample hydration. Samples (1 g) were accurately weighed in the graduated test tube. Deionized water containing 0.02% sodium azide (30 mL) was added and they were hydrated at room temperature for 18 h. For WHC, the supernatant was removed by allowing the wet sample to drain on a fine-meshed wire screen. The hydrated sample was carefully removed, weighed and dried to constant weight in a forced-air oven at 105℃. WHC was expressed as the amount of water retained per gram dry sample. For WBC, the samples were centrifuged (3,000 g) for 20 min. The supernatant was removed by passing through a sintered glass crucible under applied vacuum. The hydrated residue was recorded and the sample was dried at 105℃ for 24 h to obtain dry weight. WBC was expressed as the amount of water retained per gram dry sample. For SC, the bed volume occupied by samples was recorded and swelling capacity was calculated as the volume occupied by sample divided by original sample weight.

Emulsifying capacity (EC) was measured according to the method described elsewhere[12]. Fiber samples were mixed with soybean oil at 7% (w/v) concentration and homogenized. An aliquot was then centrifuged at 3,000 g for 5 min. The percentage of total mixture that remained emulsified after centrifugation was expressed as stability index (%).

Fat binding capacity (FBC) was measured using the method described elsewhere[13] with some modifications. The sample (5 g) was added to 20 mL of soybean oil in 50 mL centrifuge tube. The content was then stirred for 30 sec every 5 min and after 30 min the tube was centrifuged at 1,600 g for 25 min. The free oil was then decanted and absorbed oil was determined by difference and expressed as mL (oil)/gram dry sample.

Morphological properties were assessed by the SEM (LEO Model 1450 VP). Samples were coated with gold before analysis.

2.4.2 Antioxidant properties

DPPH radical scavenging activity was measured according to the method described by Yen and Wu[14], with some modifications. Dietary fiber was dissolved in distilled water to obtain different concentrations (w/v), 1-5%. To 4 mL of each sample solution, 1.0 mL of 0.2 mM DPPH was added and mixed vigorously. After incubating for 30 min at room temperature, the absorbance of the resulting solution was measured at 517 nm using a spectrophotometer. The control was conducted in the same manner, except that distilled water was used instead of the sample. DPPH radical scavenging activity (%) was calculated as Eq. 1 described earlier.

Reducing power was determined by the method of Oyaizu[15] with some modifications. The sample solutions of different concentrations (w/v), 1-5%, were mixed with 2.5 mL of 0.2 M phosphate buffer (pH 6.6) and 2.5 mL of potassium ferricyanide. The mixtures were incubated at 50℃ for 20 min. An aliquot (2.5 mL) of 10% trichloroacetic acid was added to the mixture, followed by centrifugation at 3,000g for 10 min. The upper layer of the solution was mixed with 2.5 mL of distilled water and 2.5 mL of 0.1% ferric chloride and the absorbance was read at 700 nm using a spectrophotometer. Increased absorbance of the reaction mixture indicates increasing reducing power.

2.5 Statistical analysis

Analysis of variance (ANOVA), test of significance and comparison of means using the DMRT and paired test were performed using SPSS version 17 with a confidence level of 95%.

3 Results and Discussions

3.1 Antioxidant properties of the fine particles

Antioxidant properties as evaluated by total phenolic content, DPPH radical scavenging and inhibition of linoleic acid peroxidation are shown in Table 2. It can be seen that the fine particles extracted from organic cold pressed vegetable oils exhibited antioxidant properties and could be

Table 2 Antioxidant properties of the fine particles.

Samples	Total phenolic content (μgGAE/g)	DPPH radical scavenging (%)	Inhibition of linoleic acid peroxidation (%)
Thai Jasmine	13.06 ± 0.33b	29.08 ± 0.15a	22.96 ± 0.29a
Riceberry	17.01 ± 0.27a	23.28 ± 0.69b	18.01 ± 0.67b
Sunflower	8.64 ± 0.33d	1.94 ± 0.45d	2.82 ± 0.66d
Sesame	9.65 ± 0.22c	4.43 ± 0.38c	5.73 ± 0.59c

Values are mean ± SD (triplicate). For each parameter (column), values with different letters are significantly different ($p \leq 0.05$).

Table 3 Physical properties of the body mask.

Samples	Color – L*	Color – a*	Color – b*	Viscosity (cP)	pH
1%	27.16 ± 0.40a	0.86 ± 0.05d	1.79 ± 0.05d	1,408 ± 104d	6.65 ± 0.04b
3%	24.48 ± 0.40b	1.07 ± 0.04c	2.01 ± 0.03b	2,808 ± 188c	6.67 ± 0.00b
5%	24.12 ± 0.34b	1.18 ± 0.06b	1.86 ± 0.06c	3,267 ± 146b	6.65 ± 0.00b
7%	22.95 ± 0.05c	1.27 ± 0.03a	2.10 ± 0.07a	4,025 ± 288a	6.72 ± 0.01a

Values are mean ± SD (triplicate). For each parameter (column), values with different letters are significantly different ($p \leq 0.05$).

exploited as potential novel antioxidants. Rice bran oils (both samples) showed better antioxidant properties than sesame and sunflower oils. The phenolic compounds and antioxidant activities (DPPH and inhibition of linoleic acid peroxidation) of rice bran samples were found to be much higher than those of sunflower and sesame samples. For examples, the phenolic content of Thai Jasmine and Riceberry was found to be 13.06 and 17.01 μgGAE/g respectively, while sunflower and sesame samples contained only 8.64 and 9.65 μgGAE/g respectively. This trend occurred in DPPH and inhibition of linoleic acid peroxidation values as well. Therefore, as phenolic contents increased, DPPH and inhibition of linoleic acid peroxidation also increased. This indicated that phenolic compounds played a major role in the contribution to antioxidant activities. Several phytochemicals in the fine particles could contribute to the antioxidant properties of the samples. Tocotrienols and γ-oryzanol in rice bran oils are known as powerful antioxidants[16]. In addition, bran color (as found in Riceberry) was reported as the main factor affecting phenolic concentration in rice kernel[17].

3.2 Utilization as cosmetic product (body mask)

The mixed fine particles extracted from organic vegetable oils were successfully added to the oil phase of body mask formula. The addition of the mixed fine particles affected the texture of the body mask as evaluated by 30 test panelists (data not shown). The higher amount of the mixed fine particles caused strong smell and high viscosity. Although, body mask texture became thicker as more of the mixed fine particles were added, but they could still be easily washed out from the skin by water. In terms of physical properties (Table 3), it can be clearly seen that the addition of the mixed fine particles affected all physical properties especially viscosity and color. Color-L* which represented the whiteness of the samples decreased as more fiber was added. In addition, the viscosity of the samples was increased tremendously from 1,408 to 4,025 cP when the fiber content was increased from 1 to 5%. This was influenced by the components of the fine particles especially crude oils and fibers. However, the use of the fine particles extracted from cold pressed vegetable oils could benefit cosmetic products as they contained phytochemicals as well as radical scavengers as shown previously. There has been an increase of research on the application of radical scavengers as beneficial anti-aging and photoprotection ingredients in cosmetic products[18].

The accelerated stability test of the body mask added with mixed fine particles is shown in Table 4. After the 5-cycle of the heating-cooling cycle, color-b*, viscosity and pH were found to be significantly different from the fresh sample ($p > 0.05$). Viscosity and pH are the important quality characteristics of the cosmetic products. The addition of the mixed fine particles caused the increase of viscosity and pH, as well as tickled the changes in color-b* after the 5-cycle stability test. Therefore, the application in the industry should be carried out with extra care.

3.3 Utilization as food ingredient (dietary fiber)

Table 5 shows the dietary fiber composition of the samples. As illustrated, the fine particles extracted from different cold pressed vegetable oils were found to be the good source of dietary fiber. The content of total fiber ranged from 17.91–23.83 g/100 g dry sample. The major

Table 4 Accelerated stability test of the body mask.

Samples	Color-L*		Color – a*		Color – b*		Viscosity (cP)		pH	
	0-cycle	5-cycle	0-cycle	5-cycle	0-cycle	5-cycle	0-cycle	5-cycle	0-cycle	5-cycle
1%	27.16 ± 0.40	26.17 ± 0.62	0.86 ± 0.05	0.54 ± 0.14*	1.79 ± 0.05	0.22 ± 0.04*	1,408 ± 104	2,408 ± 298*	6.65 ± 0.04	6.92 ± 0.01*
3%	24.48 ± 0.40	23.57 ± 0.22	1.07 ± 0.04	1.02 ± 0.00	2.01 ± 0.03	0.79 ± 0.05*	2,808 ± 188	3,467 ± 315*	6.67 ± 0.00	6.93 ± 0.02*
5%	24.12 ± 0.34	22.74 ± 0.07	1.18 ± 0.06	1.12 ± 0.02	1.86 ± 0.06	0.72 ± 0.07*	3,267 ± 146	6,758 ± 679*	6.65 ± 0.00	6.81 ± 0.05*
7%	22.95 ± 0.05	21.94 ± 0.02	1.27 ± 0.03	1.19 ± 0.11	2.10 ± 0.07	0.51 ± 0.05*	4,025 ± 288	9,993 ± 1,733*	6.72 ± 0.01	6.82 ± 0.01*

Values are mean ± SD (triplicate). For each parameter (0 and 5-cycle), values with * indicate significant difference by paired test ($p \leq 0.05$).

Table 5 Dietary fiber composition of the defatted fine particles extracted from organic cold pressed vegetable oils.

Samples	Insoluble dietary fiber	Soluble dietary fiber	Total dietary fiber
	(g/100 g dry sample)		
Thai Jasmine	12.86 ± 0.71c	5.05 ± 0.10b	17.91 ± 0.62b
Riceberry	14.45 ± 0.55bc	6.35 ± 0.15a	20.80 ± 0.70ab
Sunflower	21.60 ± 1.25a	2.23 ± 0.28d	23.83 ± 0.97a
Sesame	16.97 ± 0.64b	3.00 ± 0.01c	19.97 ± 0.66b

Values are mean ± SD (triplicate). For each parameter (column), values with different letters are significantly different ($p \leq 0.05$).

component was found to be the insoluble fraction. Rice brans from both rice varieties (Thai Jasmine and Riceberry) contained the higher amount of soluble dietary fiber than those from sunflower and sesame samples. It has been well reported that cereal, fruit and vegetable by-products can be recovered and used as value added products. They supply dietary fiber as well as bioactive compounds, providing economic benefit to the food, cosmetic and pharmaceutical industries[6]. Total dietary fiber content from rice bran was reported to be in the range of 27–33 g/100 g dry sample[19, 20] while sesame coat contained about 32 g/100 g dry sample[21]. In addition, the crude fiber contents of oilcakes, the major by-product of the oil expelling industry, of canola, coconut, cottonseed, groundnut, mustard, olive, palm kernel, sesame, soybean and sunflower were summarized and reported to be 9.7, 10.8, 15.7, 5.3, 3.5, 40.0, 37.0, 7.6, 5.1 and 13.2% respectively[22].

3.3.1 Physical and morphological properties

Table 6 shows the physical properties of the defatted fine particle samples. In addition, Fig. 1 shows the SEM images of the samples. It is obvious that the color reflects the source of the fine particles. Generally, the color of all samples is quite dark as evidenced by lower L* values. This may limit the use of fine particles as dietary fiber sources in some food products. Alternatively, further treatment such as color bleaching may be required.

Although, the fine particles used as the source of dietary fibers in this paper were not taken from oilcakes, the major by-product of the oil expelling industry. However, the major components of the fine particles could be the same as oilcakes. Their majority composition would be the fine oilcake particles that passed through the screen during screw pressing and contaminated into the crude oils. SEM images revealed the morphological properties of the samples. Rice bran particles were observed clearly in Fig. 1 (a, b), while Fig. 1 (c, d) showed the particles that were the parts of seed coats of sunflower and sesame.

In terms of hydration properties, water holding, water binding and swelling capacity were determined. Water holding and/or binding of all the fiber samples were found to be in the range of 3–6 g/g. These values are considerably low when comparing to the fibers extracted from other sources. WHC of fibers from defatted rice brans were previously reported as approximately 4–5 g/g[19, 20]. The hydration properties of dietary fibers are related to the chemical structure of the component polysaccharides, and other factors such as porosity, particle size, ionic form, pH, temperature, ionic strength, type of ions in solution and stresses upon fibers. The ability of dietary fibers to hold water is strongly related to the source of the dietary fiber. Generally, dietary fibers from algae have a greater affinity for water and oil than those from fruit juice by-products. Cereal derivatives present the lowest affinity. These differences are related to the chemical properties of the fibers[6]. In addition, swelling capacity was found to relate to water holding/binding capacity. The values of swelling capacity of the fiber samples in this study were in the range of 3.1–3.3 mL/g. The water interacts with fibers through two mechanisms, water held in capillary structures as a result of surface tension strength and interaction with molecular components through the hydrogen bond or dipole forms[23]. Bulk density (about 330–446 mg/mL as found in this study) could also influence the capillary structure and surface tension.

Alongside their hydration properties, fibers exhibited the

Table 6 Physicochemical properties of the defatted fine particles extracted from organic cold pressed vegetable oils.

Samples	Color-L*	Color-a*	Color-b*	Water holding capacity (g/g)	Water binding capacity (g/g)	Swelling capacity (mL/g)	Bulk density (mg/mL)	Fat binding capacity (mL/g)	Emulsifying capacity (%)
Thai Jasmine	67.80 ± 0.53a	4.93 ± 0.58b	20.30 ± 0.17a	5.17 ± 0.16b	5.65 ± 0.01b	3.09 ± 0.05b	438.78 ± 0.13a	2.16 ± 0.09bc	15.86 ± 0.75b
Riceberry	51.57 ± 0.90b	6.03 ± 0.58a	12.63 ± 0.05c	5.91 ± 0.23a	6.44 ± 0.06ab	3.31 ± 0.10a	445.98 ± 0.24a	2.29 ± 0.01ab	19.48 ± 0.44a
Sunflower	51.17 ± 1.15b	3.20 ± 0.00d	15.20 ± 0.10b	4.80 ± 0.12b	6.53 ± 0.13a	3.09 ± 0.12b	392.45 ± 0.62b	2.11 ± 0.11c	15.45 ± 0.08b
Sesame	48.10 ± 0.72c	3.90 ± 0.10c	12.80 ± 0.10a	3.90 ± 0.26c	4.56 ± 0.20c	3.20 ± 0.93ab	329.92 ± 0.92c	2.40 ± 0.03a	18.74 ± 0.42a

Values are mean ± SD (triplicate). For each parameter (column), values with different letters are significantly different ($p \leq 0.05$).

capacity to hold oil as expressed by fat binding capacity (about 2.1–2.4 mL/g found in this study). Fat absorption of fiber particles may be related to surface properties of the particles, overall charge density and the hydrophilic nature of the constituents[24, 25].

Water holding/binding capacity, swelling and fat binding suggest some possibilities for the use of fibers as ingredients in food products. Dietary fibers with a high fat binding allow the stabilization of high-fat food products or emulsions. Dietary fibers with high water holding can be used as functional ingredients to avoid syneresis and modify the viscosity and texture of some formulated foods[26].

Moreover, the emulsifying capacity of the fiber samples in this study was found to be in the range of 15–19% which is lower than the stability index recommendation (50%)[19]. This suggests that they are not the good emulsifiers. However, considering all the physical properties of the studied fiber sources, they can be used as sources of dietary fibers in food products especially those that do not require textural changes.

3.3.2 Antioxidant properties

Antioxidant properties as evaluated by DPPH and reducing power are shown in Figs. 2 and 3. In general, antioxidant properties of all fiber samples increased with the increase of concentration. At the same concentration, Riceberry fiber exhibited the highest antioxidant properties as observed by both DPPH and reducing power. Riceberry is Thai pigmented (purple) rice that has been recently developed with the aim of providing optimum nutritional benefits. The bran part is believed to be high in antioxidants and other significant constituents, such as anthocyanins, *etc*., that possess chemopreventive properties[27]. Recently research investigations have suggested that pigmented rice and its bran extracts show higher anti-oxidative activities than non-pigmented varieties. It has been found that ferulic acid, a strong membrane anti-oxidative agent found in pigmented rice bran, is an effective constituent that prevents carcinogen-induced oral and colon carcinogenesis in rats[28, 29].

Fiber extracted from rice bran has been reported to show potential antioxidant activity[20, 30]. This study demonstrated that the fibers from seed coats e.g. sunflower and sesame also exhibit antioxidant properties. They could be used as the antioxidant dietary fiber or a product containing significant amounts of natural antioxidants associated with the fiber matrix. Antioxidant dietary fiber has been proposed as the healthy food ingredient[31].

4 Conclusions

There is a rising interest in the utilization of agricultural production by-products for cosmetic, pharmaceutical and food applications. Research focusing on antioxidant prop-

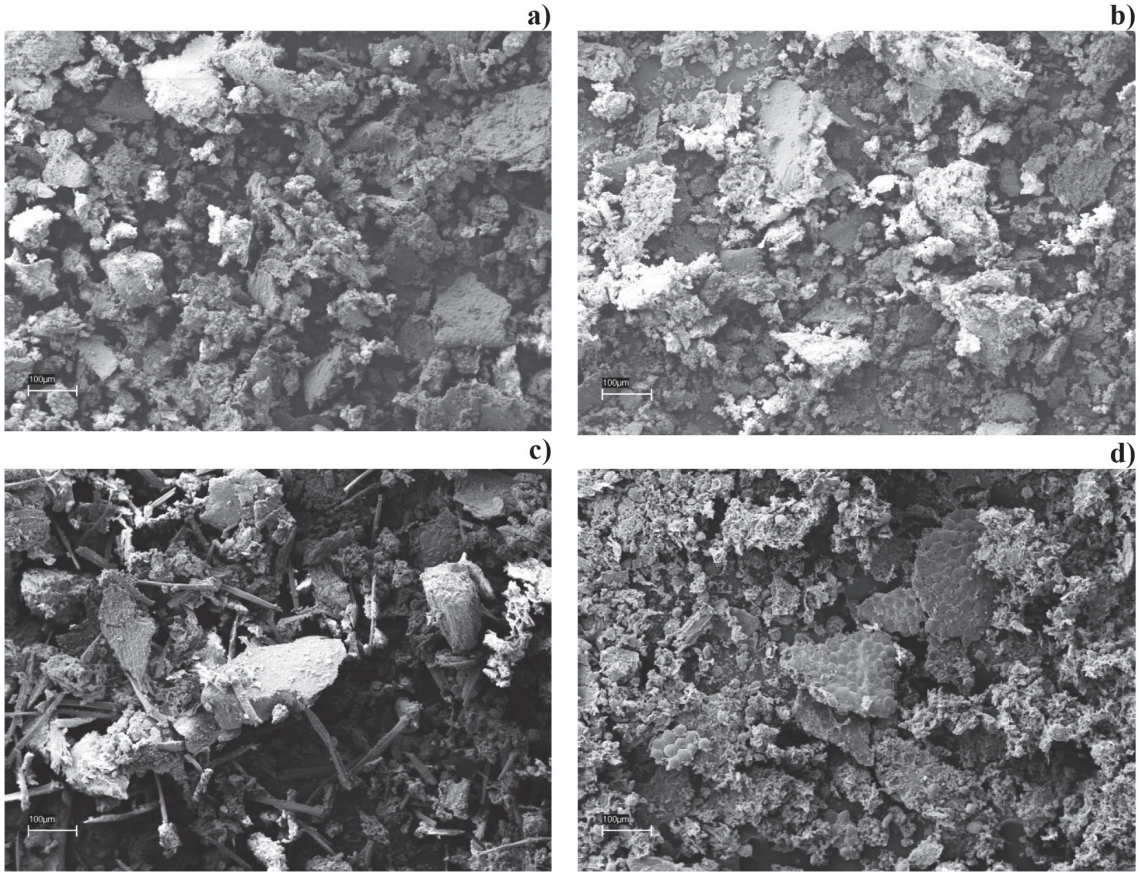

Fig. 1 SEM images of the fine particles extracted from cold pressed vegetable oils; a) Thai Jasmine, b) Riceberry, c) Sunflower and d) Sesame. Bar represents 100 μm.

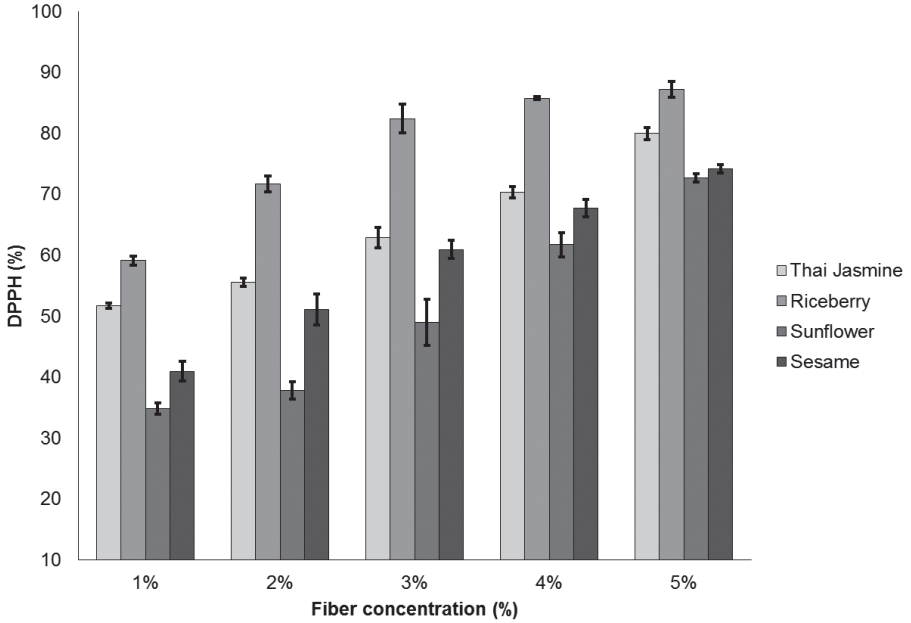

Fig. 2 Antioxidant activity of the fiber samples at various concentrations as expressed by DPPH radical scavenging (average values and SD bars, triplicate).

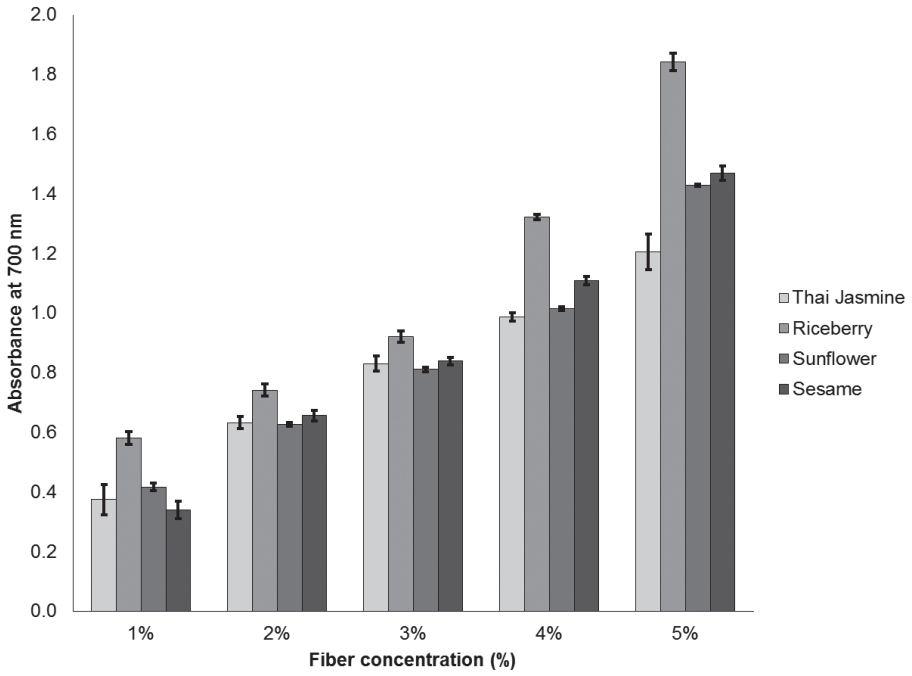

Fig. 3 Antioxidant activity of the fiber samples at various concentrations as expressed by reducing power (average values and SD bars, triplicate).

erties of those by-products is also increasing, anticipating "zero waste" awareness by the consumers. This paper successfully demonstrated the use of the fine particles extracted from organic cold pressed vegetable oils as the ingredients for body mask and sources of dietary fiber. The cold pressed vegetable oils by-products showed potential antioxidant properties and could be used for both non-food and food applications.

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