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RESEARCH ARTICLE

Parameters affecting oil extraction from rambutan (*Nephelium lappaceum* L.) seed

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ABSTRACT

Rambutan (*Nephelium lappaceum* L.) seed is commonly discarded as waste. This seed contains abundant fat that is a valuable source for vegetable oil production. To utilize this seed as a potential oil source for the human diet, this research investigated some technical variables in solvent extraction affecting the yield and quality of vegetable oil. The present research focused on the effect of particle seed size (48-28 mesh sieve), mixture of ethanol/ethyl acetate (1/1, 2/1, 3/1, 1/2, 1/3), solvent to solid ratio (5/1, 6/1, 7/1, 8/1, 9/1), extraction temperature (40–60 °C) and extraction time (30–90 min). Results showed that rambutan seed should be finely ground to 35 mesh sieve, soaked with ethanol/ethyl acetate (3/1, v/v) for 30 min, solvent/material ratio (7/1, v/w), extraction temperature (50 °C) in 60, 75, 90 min to obtain the high recovery efficiency (95.70±0.01 %) and medium antioxidant potential (total phenolic content: 14.97±0.01 mg GAE/g, total carotenoid content: 109.58±0.02 mg/kg); the low percentage of inhibition to radical DPPH (20.45±0.00 mg/ml), low peroxide value (1.49±0.03 mEq/kg), acid value (1.39±0.02 mg KOH/gm), iodine value (18.27±0.00 gm/100 gm), saponification value (86.15±0.03 mg KOH/gm). Comparing to TCVN 7597: 2013, the extracted rambutan seed oil had oxidative indicators within the acceptable limit. This rambutan seed oil would be a potential ingredient for cosmetic and personal health care industries.

Introduction

There has an increasing demand for vegetable oil from different plant sources (1). Solvent extraction is one of the most beneficial extraction methods widely used to collect vegetable oil from oilseeds with excellent recovery efficiency, consistent manipulation, and less residual oil remained in the cake (2, 4). However, solvent extraction also revealed disadvantages like extended extraction duration, relatively high solvent involvement, high investment, labour and energy consumption, fire issue, the release of volatile organic substances, low product quality and complicated handling steps (5, 6). The main obstacles related to the solvent extraction method are extraction duration lag and adverse thermal effects at high temperatures (7). The solvent selection relies on the optimal leaching attributes of the required solute substrate (8). Hexane, diethyl ether, petroleum ether and ethanol are universal solvents used for oil extraction. Excellent solvent-solute ratio, the relative volatility of solvent to oil, oil viscosity and polarity, price and accessibility are important indicators in choosing solvent (6, 9).

Rambutan seed is normally considered waste during fruit processing. Its seed occupies about 4.0–9.5% of the total weight of whole fruit (10). The dried seed contains abundant protein, lipid and carbohydrates (11). The amount of oil (14–41%) with high oleic acid renders the seed a potential source of vegetable oil (12). The main fatty acids include palmitic acid, stearic acid, oleic acid and arachidic acid (13). It can be roasted into instant snack food (14). Rambutan seed oil could be substituted with cocoa butter to produce the functional similarity of the cocoa butter in confectionery (15-17). Rambutan seed oil could be a potential carrier for fat-soluble vitamins (18). Apart from food utlilization, rambutan seed could be exploited for multiple applications such as bio-coagulant, personal care, bio-sorbent, biomedical, biodiesel and packaging to aleviate overload of rambutan by-products during processing (12). The main objective of our study was to verify major technical parameters such as seed powder size, the mixture of ethanol/ethyl acetate, solvent to solid ratio, extraction temperature and extraction time in solvent extraction affecting yield and quality of vegetable oil.

Materials and Methods

Material

Rambutan seed was collected from Soc Trang province, Vietnam. The raw seed was dried under sunlight for three consecutive days to the final moisture content of 9-9.5%. It was kept at room temperature, ready for oil extraction. Ethanol, ethyl acetate, glacial acetic acid, cyclohexane, potassium iodide, sodium thiosulfate and other chemical reagents were all analytical grade (> 99 % in purity) purchased from Sigma-Aldrich, Merck, Systerm was utilized during experiments.

Experiments

Experiment 1

Effect of seed powder size on recovery efficiency and antioxidant stability of the oil. Seed was finely ground into various sizes (48, 42, 35, 32, 28 mesh sieve). Seed powder was soaked with ethanol/ethyl acetate (1:1, v/v) for 30 min, solvent/material ratio (5/1), extraction temperature 40 °C in 45 min in Erlenmeyer flasks placed in a horizontal incubator shaker (New Brunswick™ Innova® 2350) at 120 rpm to obtain crude oil. It was then filtered through Whatman paper No. 4 under vacuum pressure to get edible oil.

Experiment 2

Effect of solvent on recovery efficiency and antioxidant stability of the oil. The seed was finely ground to 35 mesh sieve. Seed powder was soaked with different solvent mixtures of ethanol/ethyl acetate (1/1, 2/1, 3/1, ½, 1/3, v/v) for 30 minutes, solvent/material ratio (5/1), extraction temperature 40 °C in 45 min in Erlenmeyer flasks placed in a horizontal incubator shaker (New Brunswick™ Innova® 2350) at 120 rpm to obtain crude oil. It was then filtered through Whatman paper No. 4 under vacuum pressure to get edible oil.

Experiment 3

Effect of solvent/material ratio on recovery efficiency and antioxidant stability of the oil. The seed was finely ground to 35 mesh sieve. Seed powder was soaked with ethanol/ethyl acetate (3/1, v/v) for 30 min, different solvent/material ratios (5/1, 6/1, 7/1, 8/1, 9/1, v/w), extraction temperature 40 °C for 45 min in Erlenmeyer flasks placed in a horizontal incubator shaker (New Brunswick™ Innova® 2350) at 120 rpm to obtain crude oil. It was then filtered through Whatman paper No. 4 under vacuum pressure to get edible oil.

Experiment 4

Effect of extraction temperature on recovery efficiency and antioxidant stability of the oil. The seed was finely ground to 35 mesh sieve. Seed powder was soaked with ethanol/ethyl acetate (3/1, v/v) for 30 min, solvent/material ratio (7/1, v/w), extraction temperature (40, 45, 50, 55, 60 °C) for 45 min in Erlenmeyer flasks placed in a horizontal incubator shaker (New Brunswick™ Innova® 2350) at 120 rpm to obtain crude oil. It was then filtered through Whatman paper No. 4 under vacuum pressure to get edible oil.

Experiment 5

Effect of extraction time on recovery efficiency and antioxidant stability of the oil. The seed was finely ground to 35 mesh sieve. Seed powder was soaked with ethanol/ethyl acetate (3/1, v/v) for 30 min, solvent/material ratio (7/1, v/w), extraction temperature (45 °C) for different durations (30, 45, 60, 75, 90 min) in Erlenmeyer flasks placed in a horizontal incubator shaker (New Brunswick™ Innova® 2350) at 120 rpm to obtain crude oil. It was then filtered through Whatman paper No. 4 under vacuum pressure to get edible oil.

The target functions in above experiment were evaluated in respect of recovery efficiency (%), peroxide value (mEq/kg), acid value (mg KOH/gm), iodine value (gm/100 gm), saponification value (mg KOH/gm), total phenolic content (mg GAE/gm), total carotenoid (mg/kg), antioxidant activity expressed by inhibition 50% concentration or IC_{50} index (mg/ml).

Physicochemical evaluation

Oil recovery efficiency (%) was calculated by comparing the oil content obtained in the extraction and the oil content in the seeds. Peroxide value (mEq/kg), acid value (mg KOH/gm), iodine value (gm/100 gm), saponification value (mg KOH/gm) were evaluated by Soxhlet apparatus following standard methods expressed as the number of milligrams of potassium hydroxide (KOH) required to saponify 1 gram of the test sample. Total phenolic content (mg GAE/gm) was estimated by Folin-Ciocalteu reagent assay (19). Total carotenoid (mg/kg) was determined by UV/Visible spectrophotometry (Shimadzu, model 160A, Kyoto, Japan) (20). IC_{50} index (mg/ml) was identified by the percentage of inhibition to radical DPPH of one sample solution concentration (21).

Statistical summary

The demonstrations were prepared as three replicates for different sample groups. The values were expressed as mean ± standard deviation. The statistical summary was performed using Statgraphics version XVI.

Results and Discussion

Effect of seed powder size to recovery efficiency and antioxidant stability of oil

The effect of seed powder size on recovery efficiency and antioxidant stability of oil was presented in Table 1. In the range of 48-28 mesh sieve of the particle powder, target functions of the recovery efficiency (42.44±0.10 to 67.78 ±0.09 %), peroxide value (3.79±0.03 to 6.17±0.04 mEq/kg), acid value (3.06±0.04 to 5.01±0.00 mg KOH/gm), iodine value (35.79±0.02 to 62.43±0.01 gm/100gm), saponification value (158.16±0.01 to 197.56±0.03 mg KOH/gm), total phenolic content (2.59±0.04 to 3.76±0.00 mg GAE/gm), total carotenoid content (42.36±0.02 to 70.26±0.01 mg/kg), IC_{50} index (51.83±0.00 to 74.30±0.01 mg/ml) were noticed. At the seed powder size 35 mesh sieve, the oil had the highest recovery (67.48±0.09 %) and antioxidant potential (3.76±0.00 mg GAE/gm), the lowest percentage of inhibition to radical DPPH

Table 1. Effect of seed powder size to recovery efficiency and antioxidant stability of oil

Seed powder size (mesh sieve)	48	42	35	32	28
Recovery efficiency (%)	50.75±0.12^{bc}	63.07±0.07^{ab}	67.48±0.09^{a}	58.31±0.14^{b}	42.44±0.10^{c}
Peroxide value (mEq/kg)	5.40±0.05^{ab}	4.22±0.01^{bc}	3.79±0.03^{c}	4.91±0.02^{b}	6.17±0.04^{a}
Acid value (mg KOH/g)	4.64±0.02^{ab}	3.75±0.03^{bc}	3.06±0.04^{c}	4.13±0.01^{b}	5.01±0.00^{a}
Iodine value (g/100 g)	58.71±0.01^{ab}	41.63±0.00^{bc}	35.79±0.02^{c}	50.37±0.02^{b}	62.43±0.01^{a}
Saponification value (mg KOH/g)	181.35±0.00^{ab}	167.84±0.02^{bc}	158.16±0.01^{c}	174.24±0.00^{b}	197.56±0.03^{a}
Total phenolic (mg GAE/g)	2.71±0.03^{bc}	3.15±0.01^{ab}	3.76±0.00^{a}	2.86±0.02^{b}	2.59±0.04^{c}
Total carotenoid (mg/kg)	50.49±0.00^{bc}	64.15±0.02^{ab}	70.26±0.01^{a}	57.83±0.03^{b}	42.36±0.02^{c}
IC_{50} index (mg/ml)	69.85±0.03^{ab}	59.34±0.01^{bc}	51.83±0.00^{c}	64.07±0.02^{b}	74.30±0.01^{a}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

(51.83±0.00 mg/ml). Therefore the seed powder size of 35 mesh sieve was selected for the next experiments. Large powder sizes (32 and 28 mesh sieve) limited the extraction rate and decreased the oil recovery efficiency receivable within a short extraction duration. However, too small particle size (48 and 35 mesh) also encountered limitation of oil extraction capacity due to fouling effect. The large surface area could explain this behaviour accounted for by the small particle-sized powder (22). Small particle size facilitated the accessibility of the soluble substrates located inside the sample matrix (23). The yield extraction of oleoresin extracted from ginger powder was obtained much more by small particle size, especially below 250 microns (24, 25). Coarse particle size (0.5-0.75 mm) was ideal for oil extraction from Jatropha seed (26). The optimal flake thickness for extraction of sunflower cotton and soybean seeds was noticed at 2-3 mm (27). A particle size of 2 mm was adequate for the solvent extraction of soybean oil (28). The particle size of the olive cake had a great influence on oil recovery efficiency. Decreasing the particle size of the olive cake significantly improved oil yield (29). A high percentage oil yield was found at 125 µm. Particle size affected the mass transfer kinetics and facilitated solvent into the soluble components. It directly influenced the extraction potential, diffusion gradient and extractability (30). Fine particles lowered the transmission of charge in the solute mass transfer rate (31). The diffusion way for the substance inside the particle was shorter hence supporting the extraction to be more simple and quickly (32).

Influence of solvent on recovery efficiency and antioxidant stability of oil

The solvent oil extraction is quite popular to mechanical press due to its excellent oil quality with limited refining (33). The purpose of oil extraction from seed was to receive the highest recovery efficiency and the best oil quality attributes. Ethanol and ethyl acetate are friendly to the environment and highly appreciated by the food industry (34). The influence of solvent on recovery efficiency and antioxidant stability of oil was presented in Table 2. Among ethanol/ethyl acetate (1/1, 2/1, 3/1, 1/2, 1/3, v/v), target functions of the recovery efficiency (60.32±0.04 to 79.23±0.03 %), peroxide value (2.15±0.02 to 4.63±0.01 mEq/kg), acid value (2.02±0.00 to 3.71±0.02 mg KOH/gm), iodine value (23.59±0.01 to 40.63±0.03 gm/100 gm), saponification value (130.97±0.03 to 163.74±0.01 mg KOH/gm), total phenolic content (3.09±0.00 to 6.57±0.02 mg GAE/gm), total carotenoid content (66.40±0.03 to 78.26±0.00 mg/kg), IC_{50} index (40.03±0.03 to 57.19±0.02 mg/ml) were noticed. At the ethanol/ethyl acetate 3/1, the oil had the highest recovery (79.23±0.03 %) and antioxidant potential (6.57±0.02 mg GAE/gm), the lowest percentage of inhibition to radical DPPH (40.03±0.03 mg/ml). Therefore, this value was selected for the next experiments.

Ethyl acetate was not to be superior to ethanol (35). The extraction yield improved by ethanol involvement (24). Hexane was suitable for oil extraction from Jatropha seed (26). Hexane was recommended the for extraction of sunflower cotton and soybean seeds (27). Ethyl acetate with a solvent to the material ratio of 10/1 at ambient temperature would be an alternative to hexane in the oil extraction from passion fruit seeds (36). The dielectric constant of solvent for oil extraction should be in the range 6-8 (37). Ethyl acetate had a dielectric constant of 6.02, appropriate to obtain high recovery efficiency. Meanwhile, ethanol had a dielectric constant of 25.3. Complex solvent revealed a better effect than single solvent.

Impact of solvent/material ratio to recovery efficiency and antioxidant stability of oil

The influence of solvent/material ratio on recovery efficiency and antioxidant stability of oil was presented in Table 3. In different ratios of solvent/material (5/1, 6/1, 7/1, 8/1, 9/1, v/w), target functions of the recovery efficiency (78.52±0.03 to 84.32±0.01 %), peroxide value (1.67±0.00 to 2.48±0.00 mEq/kg), acid value (1.59±0.02 to 2.21±0.01 mg KOH/gm), iodine value (19.14±0.03 to 25.87±0.02 g/100 gm), saponification value (104.53±0.01 to 134.65±0.00 mg KOH/gm), total phenolic content (5.92±0.02 to 8.69±0.00 mg GAE/gm), total carotenoid content (75.19±0.01 to 89.40±0.03 mg/kg), IC_{50} index (29.83±0.02 to 42.15±0.03 mg/ml) were noticed. At the solvent/material ratio 7/1, the oil had the highest recovery (84.32±0.01 %) and antioxidant potential (8.69±0.00 mg GAE/gm), the lowest percentage of inhibition to radical DPPH (29.83±0.02 mg/ml). Therefore this value was selected for the next experiments. Solvent/material of 6/1 was ideal for oil extraction from Jatropha seed (26). The optimal solvent to solid of 1/1 was a benefit for extraction of sunflower cotton and soybean seeds (27). Solvent to solid ratio at 20/1 greatly influenced oil extraction from olive cake (29).

Table 2. Effect of ethanol/ethyl acetate to recovery efficiency and antioxidant stability of oil

Ethanol/ethyl acetate (v/v)	1/1	2/1	3/1	1/2	1/3
Recovery efficiency (%)	67.48±0.09^{bc}	75.11±0.04^{ab}	79.23±0.03^{a}	70.66±0.08^{b}	60.32±0.04^{c}
Peroxide value (mEq/kg)	3.79±0.03^{ab}	2.64±0.03^{bc}	2.15±0.02^{c}	3.10±0.03^{b}	4.63±0.01^{a}
Acid value (mg KOH/g)	3.06±0.04^{ab}	2.30±0.01^{bc}	2.02±0.00^{c}	2.81±0.04^{b}	3.71±0.02^{a}
Iodine value (g/100 g)	35.79±0.02^{ab}	26.72±0.03^{bc}	23.59±0.01^{c}	31.08±0.03^{b}	40.63±0.03^{a}
Saponification value (mg KOH/g)	158.16±0.01^{ab}	135.28±0.04^{bc}	130.97±0.03^{c}	146.12±0.01^{b}	163.74±0.01^{a}
Total phenolic (mg GAE/g)	3.76±0.00^{bc}	5.78±0.00^{ab}	6.57±0.02^{a}	4.42±0.00^{b}	3.09±0.00^{c}
Total carotenoid (mg/kg)	70.26±0.01^{bc}	76.40±0.01^{ab}	78.26±0.00^{a}	73.19±0.02^{b}	66.40±0.03^{c}
IC_{50} index (mg/ml)	51.83±0.00^{ab}	42.31±0.02^{bc}	40.03±0.03^{c}	46.24±0.01^{b}	57.19±0.02^{a}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

Table 3. Effect of solvent/material ratio to recovery efficiency and antioxidant stability of oil

Solvent/material ratio (v/w)	5/1	6/1	7/1	8/1	9/1
Recovery efficiency (%)	79.23±0.03^{bc}	82.58±0.02^{ab}	84.32±0.01^{a}	81.33±0.05^{b}	78.52±0.03^{c}
Peroxide value (mEq/kg)	2.15±0.02^{ab}	1.83±0.01^{bc}	1.67±0.00^{c}	1.95±0.02^{b}	2.48±0.00^{a}
Acid value (mg KOH/g)	2.02±0.00^{ab}	1.75±0.03^{bc}	1.59±0.02^{c}	1.87±0.00^{b}	2.21±0.01^{a}
Iodine value (g/100 g)	23.59±0.01^{ab}	20.36±0.02^{bc}	19.14±0.03^{c}	21.79±0.01^{b}	25.87±0.02^{a}
Saponification value (mg KOH/g)	130.97±0.03^{ab}	111.38±0.01^{bc}	104.53±0.01^{c}	120.41±0.03^{b}	134.65±0.00^{a}
Total phenolic (mg GAE/g)	6.57±0.02^{bc}	8.42±0.03^{ab}	8.69±0.00^{a}	7.67±0.01^{b}	5.92±0.02^{c}
Total carotenoid (mg/kg)	78.26±0.00^{bc}	85.17±0.02^{ab}	89.40±0.03^{a}	81.76±0.00^{b}	75.19±0.01^{c}
IC_{50} index (mg/ml)	40.03±0.03^{ab}	32.49±0.01^{bc}	29.83±0.02^{c}	36.27±0.00^{b}	42.15±0.03^{a}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

Effect of extraction temperature to recovery efficiency and antioxidant stability of oil

The influence of extraction temperature on recovery efficiency and antioxidant stability of oil was presented in Table 4. In different values of extraction temperature (40-60 °C), target functions of the recovery efficiency (82.37±0.00 to 89.57±0.02 %), peroxide value (1.37±0.01 to 1.79±0.01 mEq/kg), acid value (1.28±0.03 to 1.63±0.02 mg KOH/gm), iodine value (13.60±0.02 to 21.15±0.00 gm/100 gm), saponification value (80.32±0.00 to 109.71±0.03 mg KOH/gm), total phenolic (8.01±0.03 to 10.53±0.03 mg GAE/gm), total carotenoid (85.60±0.01 to 97.35±0.01 mg/kg), IC_{50} index (22.07±0.00 to 31.79±0.00 mg/ml) were noticed. At the extraction temperature 50 °C, the oil had the highest recovery (89.57±0.02 %) and antioxidant potential (10.53±0.03 mg GAE/gm), the lowest percentage of inhibition to radical DPPH (22.07±0.00 mg/ml). Therefore, this value was selected for the next experiments.

High temperatures (> 40 °C) were recommended to obtain a high extraction yield (24). A temperature of 68 °C was ideal for oil extraction from Jatropha seed (26). The best extraction temperature for extraction of sunflower cotton and soybean seeds was noticed at 60-65 °C (27). The temperature of 69 °C was adequate for the solvent extraction of soybean oil (28). The oil recovery efficiency accelerated with the accumulated temperature to 90 °C and tended to decrease afterwards (38). Temperature supported the oil extraction; however, it should not be over the solvent's boiling point. Optimal temperature induced a breakdown of oil cells leading to lower oil viscosity, and numerous oil siphons permitted oil to escape easily (27, 39, 40). With ethanol as solvent extraction, a significant isomerization was established in the hot temperature; however, oxidative decomposition was the predominant reaction. By ethyl acetate, the isomerization was the predominant one (4).

Table 4. Effect of extraction temperature to recovery efficiency and antioxidant stability of oil

Extraction temperature (°C)	40	45	50	55	60
Recovery efficiency (%)	84.32±0.01^{bc}	87.43±0.03^{ab}	89.57±0.02^{a}	85.71±0.03^{b}	82.37±0.00^{c}
Peroxide value (mEq/kg)	1.67±0.00^{ab}	1.41±0.02^{bc}	1.37±0.01^{c}	1.50±0.03^{b}	1.79±0.01^{a}
Acid value (mg KOH/g)	1.59±0.02^{ab}	1.34±0.01^{bc}	1.28±0.03^{c}	1.42±0.01^{b}	1.63±0.02^{a}
Iodine value (g/100 g)	19.14±0.03^{ab}	15.68±0.00^{bc}	13.60±0.02^{c}	17.37±0.00^{b}	21.15±0.00^{a}
Saponification value (mg KOH/g)	104.53±0.01^{ab}	87.21±0.03^{bc}	80.32±0.00^{c}	95.40±0.02^{b}	109.71±0.03^{a}
Total phenolic (mg GAE/g)	8.69±0.00^{bc}	10.18±0.02^{ab}	10.53±0.03^{a}	9.41±0.01^{b}	8.01±0.03^{c}
Total carotenoid (mg/kg)	89.40±0.03^{bc}	93.64±0.01^{ab}	97.35±0.01^{a}	91.38±0.03^{b}	85.60±0.01^{c}
IC_{50} index (mg/ml)	29.83±0.02^{ab}	25.40±0.03^{bc}	22.07±0.00^{c}	27.14±0.02^{b}	31.79±0.00^{a}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

Effect of extraction time to recovery efficiency and antioxidant stability of oil

The influence of extraction time on recovery efficiency and antioxidant stability of oil was presented in Table 5. In different values of extraction duration (30-90 min), target functions of the recovery efficiency (89.57±0.02 to 96.01±0.03 %), peroxide value (1.37±0.01 to 1.51±0.02 mEq/kg), acid value (1.28±0.03 to 1.60±0.00 mg KOH/gm), iodine value (13.60±0.02 to 23.71±0.03 gm/100 gm), saponification value (80.32±0.00 to 90.64±0.01 mg KOH/gm), total phenolic (10.53±0.03 to 17.85±0.02 mg GAE/gm), total carotenoid (97.35±0.01 to 121.43±0.00 mg/kg), IC_{50} index (18.74±0.01 to 22.07±0.00 mg/ml) were noticed. The extraction time should be stopped at 60 min to obtain the high recovery efficiency (95.70±0.01 %) and medium antioxidant potential (14.97±0.01 mg GAE/gm), the low percentage of inhibition to radical DPPH (20.45±0.00 mg/ml). In another report, 8 hrs of

Table 5. Effect of extraction time to recovery efficiency and antioxidant stability of oil

Extraction duration (minutes)	30	45	60	75	90
Recovery efficiency (%)	89.57±0.02^{b}	92.18±0.02^{ab}	95.70±0.01^{a}	95.91±0.02^{a}	96.01±0.03^{a}
Peroxide value (mEq/kg)	1.37±0.01^{c}	1.42±0.00^{bc}	1.49±0.03^{b}	1.50±0.01^{ab}	1.51±0.02^{a}
Acid value (mg KOH/g)	1.28±0.03^{c}	1.33±0.04^{bc}	1.39±0.02^{b}	1.47±0.03^{ab}	1.60±0.00^{a}
Iodine value (g/100 g)	13.60±0.02^{c}	16.38±0.01^{bc}	18.27±0.00^{b}	20.46±0.01^{ab}	23.71±0.03^{a}
Saponification value (mg KOH/g)	80.32±0.00^{c}	82.57±0.02^{bc}	86.15±0.03^{b}	89.12±0.00^{ab}	90.64±0.01^{a}
Total phenolic (mg GAE/g)	10.53±0.03^{c}	12.80±0.00^{bc}	14.97±0.01^{b}	16.40±0.02^{ab}	17.85±0.02^{a}
Total carotenoid (mg/kg)	97.35±0.01^{c}	101.15±0.03^{bc}	109.58±0.02^{b}	115.62±0.01^{ab}	121.43±0.00^{a}
IC_{50} index (mg/ml)	22.07±0.00^{a}	21.73±0.02^{ab}	20.45±0.00^{b}	19.80±0.00^{bc}	18.74±0.01^{c}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

extraction time was ideal for oil extraction from Jatropha seed (26). The optimal extraction duration of 5 hrs was adequate for the extraction of sunflower cotton and soybean seeds (27). Extraction time from 3.5 to 4.5 hrs induced the highest soybean oil yield (28). Oil extraction ability was improved with hr increase in extraction time (9). Fractionation time acceleration induced an increased recovery and decreased iodine value (42). Chemical attributes of rambutan seed oil showed acid value (0.37%), iodine value (37.64%) and saponification value (157.07 mg KOH/g) (43). Comparing to TCVN 7597: 2013, the extracted rambutan seed oil had oxidative indicators within acceptable limits.

Conclusion

Rambutan (*Nephelium lappaceum* L.) seed is normally considered a waste during fruit processing. We have successfully examined different parameters such as seed powder size, the mixture of ethanol/ethyl acetate, solvent to solid ratio, extraction temperature and extraction time affecting recovery efficiency, chemical quality and antioxidant attributes of vegetable oil. Rambutan seed should be finely ground to medium particle size (35 mesh sieve), soaked with a fair ratio of ethanol/ethyl acetate (3/1, v/v) for 30 min, solvent/material ratio (7/1, v/w); extraction at medium temperature (50 °C) in an appropriate duration (60 min). Rambutan seed oil obtained by this research may lead to its potential application as promising alternative edible oil to replace hydrogenated fat in specific foodstuffs as well as cosmetic patterns.

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Authors' contributions

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

Conflict of interests

The author strongly confirmed that this research was conducted with no conflict of interest.

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