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Comparative study on infrared radiation and hot air convective drying of coconut: Effect on oil quality features

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ABSTRACT

Appropriately dried coconut kernel, or copra, is imperative for oil production to ensure consistent quality, taste, aroma, and nutritional properties of the resultant coconut oil. This research assesses the effects of different drying techniques—hot air drying (HAD), infrared drying (ID), and infrared-assisted hot air drying (IAHAD)—on the quality profile of coconut oil extracted from copra. Coconut kernels were subjected to radiation and convective hot-air drying methods at varying temperatures (50 °C, 60 °C, and 70 °C). The fresh oil sample extracted from copra using different drying techniques exhibited zero peroxide value, indicating high quality. Among the methods, IAHAD at 60 °C was remarkable for producing the highest-grade copra, resulting in superior quality oil with exceptional preservation of essential nutrients. The physical and biochemical properties of the coconut oil produced using IAHAD at 60 °C included specific gravity, refractive index, moisture content, anti-oxidant capacity, and total phenolic content, all indicating enhanced oil quality.

1. Introduction

Coconut is often called the "Tree of Life" due to the multitude of products and benefits derived from its different parts [1]. Coconut palm, scientifically known as *Cocos nucifera* L., is found in tropical regions throughout the world, thriving in sandy soils in the vicinity of sea shores [2]. Coconut oil extracted from dried coconut kernels, commonly known as copra, is highly valued and has numerous food and health applications. The process of extracting oil from copra involves crushing or pressing the dried coconut meat or kernel to release the oil, which is then refined through various methods to produce different types of coconut oil [3].

Coconut oil (CO) has found multitude of utilities in both industrial and food-related applications due to the abundance of phenolic compounds associated with its radical scavenging activity or anti-oxidant potential [4]. Currently, CO is used as a dietary supplement due to its numerous benefits, such as its anti-inflammatory [5], antibacterial [6], antioxidant [7], antiviral properties [8] and its ability to boost the immune system. Coconut oil contains tocotrienols, capric acid, caproic acid, and lauric acid, all of which serve as natural antioxidants [9]. Coconut oil contains healthy saturated fats, particularly medium-chain fatty acids (MCFAs), such as lauric acid. These fats are metabolized differently in the body and can serve as a quick source of energy [10].

Most commercially available coconut oils are refined, bleached, and deodorized (RBD), and are produced through various drying methods such as sun drying, solar drying, smoke drying, or a combination of multiple drying techniques [11]. The drying method and temperature significantly influence the quality of the copra. The major drawback of existing copra drying methods is their potential to affect the quality of the final product due to uneven drying, which can lead to inconsistencies in moisture content and overall quality. In thermal food processing, the use of infrared heating has gained a wide popularity and acceptance. This method tends to preserve the nutritional content and quality of coconut, offering copra with potentially higher nutritional value compared to copra dried using conventional methods. It might minimize the risk of contamination during the drying process since it precludes direct contact between the coconut and the heat source. The combination of infrared and hot air helps achieve more uniform drying, rapid, and volumetric heating preserves the quality of copra by reducing the risk of uneven moisture content and maintaining better texture and flavour.

Recent research has focused on examining the properties of coconut

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oil extracted through various techniques [12]. To date, there are no reports on the characteristics of the oil produced by different drying methods, including hot air drying (HAD), infrared drying (ID), and infrared-assisted hot air drying (IAHAD), which are utilized to prepare copra from coconut. Hence, it is indispensable to assess the biochemical attributes of oil extracted from copra obtained via various drying techniques for comparison. Therefore, the present study is designed to evaluate the effects of drying methods (infrared, hot air, and infra-assisted hot air drying) and drying temperatures (50, 60, and 70 °C) on the quality of coconut oil.

2. Materials and methods

2.1. Materials

Fully matured coconuts, of 12 months old (Variety: WCT) were selected for copra production from the Farm Section of the ICAR-Central Plantation Crops Research Institute, Kasaragod, India.

2.2. Sample preparation

A dehusker, capable of processing 350 coconuts per hour, was used to remove the husks from the collected coconuts. The dehusked coconuts were then cut into two halves. Drying experiments on the prepared coconuts were conducted using HAD, ID, and IAHAD techniques at temperatures of 50 °C, 60 °C, and 70 °C, with a constant air velocity of 2 m/s. High temperatures increase the drying rate but also cause browning and case hardening, which is the formation of a hard outer layer that severely restricts the passage of moisture from the interior to the surface of the kernel. The infrared dryer (NP Technology, Maharashtra, India) was powered with a 415 V, 3-phase AC supply, and stainless steel (S.S) 304 tubular air heaters placed on both sides. The dryer was fitted with three infrared bulbs, each acting as a light source, and each bulb could produce 1.0 kW, resulting in a total heating rate of 3.0 kW. The dryer allowed for individual modes of ID and HAD, as well as a combined mode (IAHAD) of drying. The drying period varied for each treatment: for ID, 50 °C required 23 h, 60 °C took 21 h, and 70 °C took 19 h. For IAHAD, drying times were 19 h at 50 °C, 17 h at 60 °C, and 14 h at 70 °C.

The dried samples of copra obtained by three different methods were subjected to oil extraction. Coconut oil was extracted at 90 °C using a mini oil extractor (Model ATC/180/600 CM/22/12/2021) (Fig. 1). From each treatment, 360 g of copra samples were used to extract oil. Approximately 200 ml of oil was obtained before double filtration, and 175–180 ml of oil was obtained following double filtration performed using Whatman No. 4 paper. The extracted oil was kept for 4–5 h to ensure the settlement of solid matter, packed in 200 ml PET bottles, and stored in a dark condition.

2.3. Physical analysis of oil

2.3.1. Determination of specific gravity

The specific gravity of the coconut oil was determined by measuring the mass of the oil in a pre-weighed 1 ml tip and calculating it using Equation (1) [13].

$$\text{Specific gravity} = \frac{\textit{Density of oil}}{\textit{Density of water}} \quad (1)$$

2.3.2. Determination of the refractive index

The refractive index was determined using a handheld refractometer. One or two drops of oil were placed in the instrument's receptacle, where a light source illuminated the sample, producing °Brix readings. These readings were then converted into refractive index values using a conversion table provided by Ranganna (2012) [14].

2.4. Biochemical analysis of oil

The biochemical characteristics of the coconut oil samples were determined using standard official methods (AOAC, 2005)[15], namely, moisture (AOAC 934.2005) using the A&D MX-50 moisture analyzer (Oxfordshire, UK), iodine value (AOAC 993.20), saponification value of oil (AOAC 920.160), free fatty acid (AOAC 996.06), and peroxide value in oil (AOAC A.965.33).

2.5. Estimation of total polyphenol content

The total polyphenol content (TPC) was estimated using a modified Folin-Ciocalteu method [16]. Polyphenols were extracted from coconut oil samples with three consecutive extractions using 10 ml of 80 % ethanol. A blank was prepared with 3 ml of distilled water. Into the aliquot, 200 µl of FCR reagent and 2 ml of 7 % Na_2CO_3 were added, followed by vortexing for 2 min. The mixture was incubated for 45 min, then the absorbance was measured at 745 nm using a UV–Vis

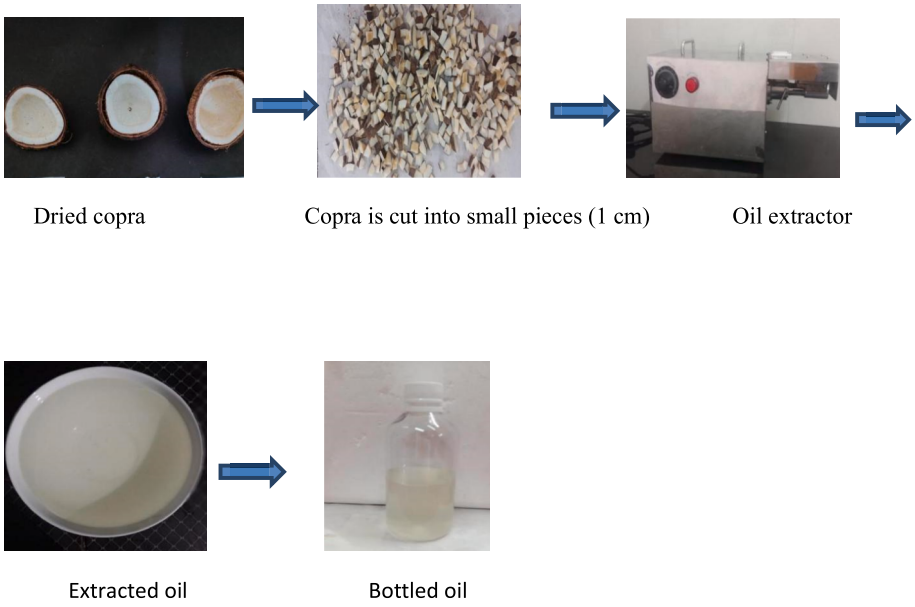

Fig. 1. Flow chart depicting the process of oil extraction.

spectrophotometer (Shimadzu, Japan). TPC was expressed as mg GAE per 100 g of coconut oil [17].

2.6. Estimation of antioxidant potential

FRAP was performed according to Benzie and Strain [46], and the 2,2-diphenylpicrylhydrazyl (DPPH) assay was carried out according to the method of Contreras-Guzman and Srong [18].

2.7. Statistical analysis

In all these experiments the parameters were carried out as three replicas, and the data was expressed in means ± standard deviation (SD). The influence of using different dryers and drying temperatures was analyzed in two factorial and completely randomized design using the Web Agri Stat Package 2.0 statistical analysis, ICAR.

3. Results and discussion

3.1. Specific gravity

Specific gravity is an important parameter in assessing the quality of coconut oil. A deviation from the standard specific gravity range might indicate the presence of foreign substances, suggesting lower quality or potential adulteration. The specific gravity of oil samples obtained from copra dried using different methods and temperatures is given in Table 1. It was observed that drying methods significantly affected the specific gravity of coconut oil samples ($p < 0.05$). The specific gravity of the oil samples ranged from 0.87 to 0.93 (Table 1). The highest specific gravity value (0.93) was obtained for the oil sample extracted from copra dried in an IAHAD at 70 °C, while the lowest value (0.87) was observed for the oil from copra that underwent hot air drying at 50 °C. These values were closely related to the standard range of 0.92 ± 0.01 approved by Codex standards.

The low specific gravity value is due to the oxidation of products that break down into low molecular weight compounds such as free fatty acids, alcohols, and aldehydes, eventually leading to rancidity. The high specific gravity value is attributed to high-temperature treatment, which results in lesser moisture content, reducing the chance of oxidation and subsequent production of fatty acids. These values align with standards and previous studies by Srivastava *et al.* [19] and Deepa *et al.* [20].

3.2. Effect on the refractive index (RI) of oil

The refractive index (RI) is the ratio of the speed of light in a vacuum to the speed of light in the oil sample. It is related to the degree of saturation and measures the purity of oil. Coconut oil has a high refractive index compared to other oils. Table 1 shows the refractive index of coconut oil obtained from copra samples dried using different methods and temperatures. There was no significant difference ($p < 0.05$) in the refractive index of all samples. According to Codex standards, the refractive index of coconut oil falls within the range of 1.448–1.450, while APCC standards specify 1.4480–1.4492. The refractive index of the oil samples is in accordance with these specified standards and is similar to the findings reported by Fakhri and Qadhir [21]. The RI of the oil increases only when the oil is deodorized, at which stage the oil becomes less polar. The findings obtained in this study are consistent with the biochemical attributes of coconut oils reported by Ramesh *et al.* [16].

Table 1
Physical properties of coconut oil obtained from different samples.

Treatment	Sample ID	Temperature (°C)	Specific Gravity	Refractive Index*
T1		50	0.87 ± 0.04^{d}	1.45 ± 0
T2	HAD	60	0.92 ± 0.00^{b}	1.45 ± 0
T3		70	0.92 ± 0.00^{b}	1.45 ± 0
T4		50	0.91 ± 0.00^{c}	1.45 ± 0
T5	ID	60	0.91 ± 0.00^{c}	1.45 ± 0
T6		70	0.92 ± 0.00^{b}	1.45 ± 0
T7	IAHAD	50	0.92 ± 0.00^{b}	1.45 ± 0
T8		60	0.92 ± 0.00^{b}	1.45 ± 0
T9		70	0.93 ± 0.00^{a}	1.45 ± 0

Note: alphabets represent the 5% level of significance, *The values are non-significant for refractive index, HAD-Hot air dryer, ID-infrared dryer, IAHAD-Infrared assisted hot air dryer.

3.3. Effect of different drying methods and temperature on moisture content in coconut oil

Maintaining low moisture content in coconut oil is essential to ensure its quality, stability, and long shelf life. Higher moisture content in coconut oil increases its susceptibility to rancidity and negatively impacts both its quality and shelf life. According to the Asian and Pacific Coconut Community (APCC, 2005), the moisture content of coconut oil should be within the range of 0.2 %-0.5 %.

The moisture content of coconut oil obtained from different copra samples is presented in Table 2. Coconut oil extracted from copra dried using IAHAD at 70 °C showed a minimal moisture content of 0.23 % ($p < 0.05$), while oil obtained via conventional hot air drying methods at 50 °C showed a comparatively high moisture level of 0.42 %. The higher moisture content observed in the hot air-dried oil could be due to considerable losses of thermal energy, low thermal conductivity, case hardening of the material, relatively long drying times, and poor quality and shrinkage of the dried product.

The efficiency of infrared technology enables faster and more effective moisture removal during drying, leading to reduced moisture content in the oil extracted from copra using an IAHAD. Mesery *et al.* [22] studied the process of biomass drying using hot air convection (HA), infrared (IR), and combined drying systems (IR-HA). A rapid reduction in the moisture content of biomass during the IR-HA drying method was observed. The internal heat generated by the IR and the hot air flow likely resulted in a rapid reduction of moisture content due to the diffusion of water to the surface of the biomass, followed by its evaporation.

3.4. Effect of different drying methods and temperature on iodine value of oil samples

The iodine value measures the degree of unsaturation of oils and fats. Unsaturated fatty acids are usually recommended for healthy consumption over a high percentage of saturated fatty acids in oils. However, highly unsaturated fatty acids in oils undergo an oxidative degradation process due to the presence of unsaturated double bond configuration unless enough antioxidant is added [23].

Table 2 presents the iodine value of different oil samples, which is in the range of 6.29 g I_2/100 g to 9.43 g I_2/100 g. However, the values comply with APCC standards for coconut oil. The highest iodine value of 9.43 g I_2/100 g was found in coconut oil that was obtained from copra air-dried with infrared assistance at 50 °C and the lowest iodine value of 6.29 g I_2/100 g was found in oil extracted from hot air-dried copra samples dried at 70 °C. IAHAD are typically more efficient in retaining the nutritional quality of oils compared to conventional hot air dryers because they operate at volumetric heating. This means that oils extracted using infrared-assisted dryers might potentially have a higher retention of iodine value due to the preservation of unsaturated fatty acids. There is also a decreasing trend in the iodine value as the temperature increases from 50 to 70 °C.

Dawodu *et al.* [24] also observed a decrease in the iodine value of vegetable oil as the temperature increased. The decrease in iodine value at higher temperatures might result from the saturation of double bonds of the given oil as the temperature increases (Al-Bachir [25]). The values

Table 2
Chemical analysis of coconut oil derived from copra produced by three different drying methods.

Treatment	Sample ID	Temperature (°C)	Moisture (w.b) %	FRAP (mg eq Trolox/ 100 g)	DPPH (mg eq Trolox/ 100 g)	Iodine value g I_2/ 100 g	Saponification value (mgKOH/g)	Free fatty acid (mgKOH/ g)	Peroxide value (meq per kg)	Total phenolic content (mg GAE/100 g)
T1	HAD	50	0.42 ± 0^{a}	5.20 ± 0.14^{c}	5.30 ± 0.03^{c}	6.60± 0.16^{gh}	225.55 ± 1.06^{f}	0.22 ± 0.02^{d}	0	4.91 ± 0.17^{f}
T2		60	0.37 ± 0^{bc}	4.45 ± 0.21^{d}	4.95 ± 0.04^{d}	6.55 ± 0.10^{h}	239.30 ± 1.13^{e}	0.46 ± 0.03^{c}	0	5.79 ± 0.20^{e}
T3		70	0.31 ± 0^{d}	3.02 ± 0.13^{f}	4.37 ± 0.10^{e}	6.29 ± 0.06^{i}	269.20 ± 1.41^{a}	0.71 ± 0.01^{a}	0	4.25 ± 0.11^{g}
T4	ID	50	0.40 ± 0^{ab}	5.21 ± 0.43^{c}	4.52 ± 0.14^{e}	8.25 ± 0.08^{d}	238.65 ± 2.10^{e}	0.20 ± 0.01^{de}	0	5.27 ± 0.12^{f}
T5		60	0.35 ± 0^{c}	6.30± 0.14^{b}	5.87 ± 0.10^{b}	7.83 ± 0.17^{e}	233.85 ± 3.20^{ef}	0.54 ± 0.02^{b}	0	7.67 ± 0.21^{b}
T6		70	0.29 ± 0^{d}	4.70 ± 0.12^{d}	5.11 ± 0.01^{cd}	7.21 ± 0.02^{f}	237.55 ± 2.86^{e}	0.67 ± 0.00^{a}	0	6.64 ± 0.46^{c}
T7	IAHAD	50	0.30 ± 0^{d}	6.46 ± 0.23^{a}	5.85 ± 0.10^{b}	9.43 ± 0.21^{a}	247.75 ± 2.05^{d}	0.07 ± 0.04^{f}	0	7.38 ± 0.03^{b}
T8		60	0.27 ± 0^{d}	6.76 ± 0.23^{a}	6.15 ± 0.10^{a}	9.04 ± 0.17^{b}	249.70 ± 2.12^{c}	0.14 ± 0.02^{e}	0	9.41 ± 0.19^{a}
T9		70	0.23 ± 0^{e}	3.59 ± 0.53^{e}	4.65 ± 0.03^{e}	8.54 ± 0.06^{c}	261.40 ± 1.13^{b}	0.20 ± 0.00^{d}	0	6.40 ± 0.19^{cd}

Note: alphabets represent the 5 % level of significance, *The values are non-significant for refractive index, HAD-Hot air dryer, ID-Infrared dryer, IAHAD-Infrared assisted hot air dryer.

described in the literature by Martins *et al.* [26] for the iodine value for coconut oil samples are generally presented as a value range, rather than a fixed number, because the degree of unsaturation may vary according to several aspects, mainly due to the seasonality of the oil seed or depending on different types of oil processing.

3.5. Effect of different drying methods and temperature on saponification value of oil

The saponification value is an index of the average molecular mass of fatty acids in oil samples, and it is inversely proportional to the length of the fatty acid chain. According to Codex Alimentarius and the APCC Standards, the saponification value of coconut oil is in the range of 250–265 and 248–268 mg of KOH / g of oil respectively.

The saponification value obtained from the oil is given in Table 2 and shows that values ranged between 225.55 to 269.20 mg KOH/g. The maximum saponification value was observed for the oil sample from the HAD copra sample at 70 °C. The saponification value of the oil sample produced by IAHAD methods was within the limit of the APCC standards of saponification value for coconut oil. The low saponification values observed, compared to the APCC and Codex Alimentarius standards, might be due to a high level of impurities. As noted by [27], high saponification values in almond seed oil indicate low impurity levels. A study done by Oseni *et al.* [28] reported that the high saponification value of coconut oil is attributed to the presence of short and medium chain triglycerides. The high saponification value of oil samples is an indication of vegetable oil for industrial applications such as soaps and shampoo, pharmaceuticals, and food processing [29].

3.6. Effect of different drying methods and temperature on free fatty acids (FFA) in coconut oil

FFA can be used as an indicator to evaluate the organoleptic quality (taste and aroma) of coconut oil. High levels of free fatty acids (FFA) in oil leads to the development of a rancid taste and aroma, causing a rejection based on its sensory quality [30]. During extraction and storage, FFAs may develop through reactions involving the residual water in the oil. Hydrolysis can take place via chemical or enzymatic processes, which may involve lipases from native plant enzymes or microbial contaminants [31]. The FFA content of different oil samples is listed in Table 2. The table shows that the highest FFA content of 0.71 mg KOH/g was observed in copra oil extracted which is HAD at 70 °C. This is because high temperatures can accelerate the breakdown of triglycerides into free fatty acids and glycerol. However, the FFA content of the samples was within the limits of the Codex and APCC standards. According to the Codex Alimentarius (2005), the maximum allowable free fatty acid content for coconut oil is 4 mg KOH/g oil. This indicates that none of the oil samples show any signs of rancidity.

The lower value of FFA (0.07 mg KOH/g) was observed for IAHAD at 50 °C. IAHAD methods might have certain advantages in terms of potentially minimizing heat exposure. Mahesar et al.[32] observed that the level of FFA content depends on time, temperature, and moisture content because if the oil is exposed to various environments such as storage, processing, and heating since FFAs are less stable, they are prone to oxidation and turn to rancid. Panjaitan et al.[33] also endorsed that coconut oil with low free fatty acid (FFA) is suitable for human consumption. Coconut oil with low FFA content is preferable, properly dried copra with low moisture content (≤6 %) has a low FFA content and has good quality [34].

3.7. Effect of different drying methods and temperature on peroxide value of coconut oil

The peroxide value is the common indicator of rancidity. Peroxides are formed in oil when the triglycerides are oxidized in the presence of moisture. Fresh oils typically have peroxide values below 10 meq/kg, whereas values between 20 and 40 can lead to a rancid taste characterized by an unpleasant odor [35]. In the present study, the peroxide

value of the oil samples was zero, because the samples do not have peroxides. A high value of PV indicates a high value of oxidative rancidity and a low level of antioxidant value of oil [36]. Abiodun *et al.* [37] found that the amount of peroxidation increases at room temperature with storage time, while the high values noticed in the local oils may be due to conditions occurred during drying and extraction as exposure to light and heat increases the rate of lipid oxidation. The peroxide value determines the extent to which the oil has undergone rancidity. Otamiri *et al* [35] conducted a study on the physicochemical properties of copra oil and reported a peroxide value of 3.02 meq/kg. The low peroxide value could be attributed to the oil's low unsaturated fatty acid content, as well as careful storage and handling during and after extraction to prevent contaminants.

3.8. Effect of different drying methods and temperature on total phenol content in oil

The total phenol content within the oil serves as a measure of the presence of bioactive elements such as antioxidants, antimicrobial agents, and anti-inflammatory compounds [38]. The TPC of oil samples extracted from different copra samples is mentioned in Table 2, which was found to be in the range of 4.25 to 9.41 mg GAE/100 g. A high TPC value of 9.41 mg GAE/100 g was observed for the oil sample dried by IAHAD at 60 °C and the lowest TPC value of 4.25 mg GAE/100 g was observed for the oil sample dried by a hot air dryer at 70 °C. The values are consistent with the TPC values reported by Ramesh *et al.*[16].

Generally, infrared radiation can improve nutrient retention such as total phenolic content and antioxidant activity compared to other drying techniques [39]. Here, minimal degradation of phenolic compounds occurs as a result of the volumetric heating of IAHAD, resulting in reduced damage to the cellular structure. The total phenolic content showed an increase until reaching 60 °C and then decreased to 70 °C in all drying techniques. Snoussi et al. [40] also observed a similar pattern in the total phenolic content of ethanol extracts from *Myrtus communis* L. leaves. Losses of TPC, especially at high temperatures, could be due to thermal degradation, have also been reported by other authors [41].

It is also observed that high temperatures and prolonged heating during hot air drying might degrade or reduce the concentration of these compounds, resulting in a lower overall phenolic content in the extracted oil. Several studies revealed that the difference in total phenolic content in coconut oil could be attributed to the different production methods.

3.9. Effect of different drying methods and temperature on antioxidant activity in coconut oil

The antioxidant property of coconut oil is given in Table 2. The FRAP value of different oil samples ranged from 3.02 mg eq Trolox/100 g to 6.76 mg eq Trolox/100 g. The coconut oil sample extracted from copra dried by IAHAD at 60 °C was found to have a high FRAP value and the lowest value (3.02 mg eq Trolox/100 g) was observed for HAD at 70 °C. In case of the DPPH value of the oil samples, it was observed to be in the range of 4.37 to 6.15 mg eq Trolox/100 g. The maximum value accounts for IAHAD at 60 °C and the lowest value for HAD at 70 °C. A significant reduction in natural antioxidant activity was observed at 70 °C, most likely due to intense thermal treatment, primarily because many of these compounds are unstable [42].

Statistical analysis shows that the level of significance for FRAP and DPPH was 5 %. The antioxidant activity obtained from the oil samples was significantly related to the total phenolic content. Therefore, the high phenolic content might be attributed to the high antioxidant activity in the oil samples obtained from IAHAD. Combining infrared with hot air drying synergistically harvests the benefits of both methods, leading to shorter drying times and lower temperature exposure [43]. This synergy helps retain more antioxidants than either method alone. Infrared-assisted hot air drying significantly reduces drying time, reducing exposure to oxygen and heat, which can degrade antioxidants. This minimizes degradation and better preserves antioxidant activity. The variation in the antioxidant activity of the coconut oil samples could be due to various factors, such as the quality of the raw materials, the storage condition, and the extraction method [44].

Nivya *et al.*[45] found that the difference in antioxidant activity of VCO is due to the difference in processing techniques and due to thermal treatment. Mulyadi et al.[7] reported that VCO extracted by the dry method has the lowest antioxidant value and the wet method has a high antioxidant value. It is due to the destruction of polyphenols by heat. Infrared radiation enhances the TPC and antioxidant content of the food sample to some extent [39].

4. Conclusions

The choice of copra drying technique significantly influences the quality of the resultant oil. This study showed that the infrared-assisted hot air drying (IAHAD) method generally produces coconut oil with superior quality compared to ID (IFD) or hot air drying (HD) alone. The main advantages of infrared drying compared to convective hot air drying are faster drying, better product quality, and greater energy efficiency. Specifically, IAHAD exhibited improved preservation of beneficial compounds, better oxidative stability, and improved overall quality attributes in the extracted coconut oil. The IAHAD method at 60 °C is the optimal choice for producing high-grade copra, resulting in a moisture content of 0.27 % (w.b), FRAP value of 6.76 mg eq Trolox/100 g, DPPH value of 6.15 mg eq Trolox/100 g, iodine value of 9.04 g I_2/100 g, saponification value of 249.7 mg KOH/g, free fatty acid value of 0.14 mg KOH/g and TPC of 9.41 mg GAE/100 g. The physicochemical properties of oil samples were within the acceptable range recommended by the APCC. This optimization could lead to increased productivity for coconut processors, making their operations more competitive in the market. The findings suggest that the combination of infrared and hot air drying techniques positively impacts the quality of copra and subsequently coconut oil, presenting a promising approach to obtain higher-quality oil with improved characteristics. Future experiments should explore the feasibility of large-scale continuous infrared drying in coconut processing, given its significant impact on the quality of the dried product.

CRediT authorship contribution statement

R. Pandiselvam: Writing – review & editing, Writing – original draft, Resources, Investigation, Funding acquisition, Conceptualization. **Sneha Davison:** Methodology, Investigation, Formal analysis. **M.R. Manikantan:** Writing – original draft, Visualization, Supervision, Project administration, Investigation. **Anjitha Jacob:** Methodology, Investigation, Formal analysis. **S.V. Ramesh:** Validation, Methodology, Investigation. **Shameena Beegum:** Software, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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