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Impact of roasting on the changes in composition and quality of cashew nut *(Anacardium occidentale)* oil

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Abstract

Oils from cashew nut were extracted by an oil cold-extraction with petroleum ether and then, their properties were investigated as affected by roasting process at 150^{O}C for 30 and 60 min. The oil yield of roasted cashew nut oil (30.67-31.67%) was significantly higher compared to unroasted oil (27.33%). The roasting process significantly caused a color development in the oil. The oil mainly consists of monounsaturated fatty acids (~64% of total fatty acids), followed by saturated and polyunsaturated fatty acids, respectively. The predominant monounsaturated fatty acid present in both unroasted and roasted oils was oleic acid (63.61-64.12%), whilst linoleic acid (16.19-17.19 %) was the most abundant polyunsaturated fatty acid with a lesser amount of linolenic acid. The primary saturated fatty acids identified in the oils were palmitic acid (11.68-12.27%) and stearic acid (6.15-7.38%), respectively. The crystallization and melting temperatures of all oil samples were comparable values, in relevance with their fatty acid composition. The reduction in α- tocopherol of roasted oil compared to raw oil was found. The results of the study indicated that the cashew nut kernels constitute a viable source of certain health-beneficial compounds, whereas roasting caused significant losses of bioactive compounds in cashew nut oil.

Introduction

Cashew tree *(Anacardium occidentale)* is a native of Brazil and the lower Amazons, afterwards it widely cultivated as a potential commercial crop throughout the tropical climate regions, particularly in Africa and Asia such as Kenya, Madagascar, Nigeria, India, Srilanka and Thailand (Rosengarten, 1984). Cashew fruit comprises of cashew apple, cashew nut shell and cashew nut kernel. Cashew apple can sometimes be made locally into a number of food products such as wines, pickles, jam, syrup and beverage. On the other hand, cashew nut shell might be used in industry as a water proofing agent, a raw material for brake lining compounds, and a preservative for paints and plastics manufacturing. Cashew nut kernel is an edible nut which can be considered as rich sources of lipids and proteins (Achal, 2002). Interestingly, edible oil extracted from cashew nut kernel is also possible.

The roasting process is a key step for making some oils such as sesame oil (Yoshida and Kajimoto, 1994), safflower oil (Lee *et al.*, 2004) and rice germ oil (Kim *et al.*, 2002). The roasting conditions have significant influences on oil's characteristics (i.e. color, flavor, fatty acid profile and bioactive compounds) that are transferred to the oil upon extraction (Kim *et al*., 2002; Yen, 1990; Yoshida and Takagi, 1997). In addition, fatty acid composition and natural antioxidative compounds, which namely referred to tocopherol, strongly effect on deterioration of the oil, particularly oxidation, during processing and storage. Tocopherol has been labeled as the most efficient antioxidant particularly α-tocopherol that plays an antioxidant role to control or reduce lipid peroxidation (Packer, 1995). Therefore, the oil quality changes as affected by roasting process seem to be highly related to the stability of the oil (Yen, 1990).

Recently, only very few researches have been published describing a limited number of characteristics of cashew nut oil, espeacially the effect of roasting process. Therefore, the study aimed to investigate the effect of roasting at 150^{o}C for 30 and 60 min on the physical (i.e. viscosity and color development), chemical (i.e. fatty acid profile and α-tocopherol content), and thermal (i.e. melting and crystallization profiles) properties of cashew nut oil.

Materials and Methods

Cashew nut oil extraction

Cashew nut *(Anacardium occidentale)* which

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originates from Thailand was roasted at 150°C for 30 min and 60 min in a hot-air oven. After that, raw (unroasted) and roasted cashew nuts were ground, extracted with petroleum ether (50 g of cashew nut : 150 ml of petroleum ether) at room temperature for 2 h with a constant stirring and vacuum filtered with Whatman No. 1 filter paper to remove the nut residue. After that, the oil was recovered by evaporating the solvent using a rotary evaporator at 35°C in a vacuum and stored in the dark at -18°C until further analysis.

Analytical methods for chemical composition

For fatty acid composition analysis, triacylglycerols in the oils were converted into the corresponding fatty acid methyl esters and analyzed by GC (Hewlett Packard 5890A) equipped with a DW-wax column (30 m x 0.25 mm I.D. x film 0.25 µm, J&W Scientific, USA) with a flame ionization detector (Liaotrakoon *et al.*, 2013). Nitrogen was used as the carrier gas. Peak identification was based on retention time comparison with a standard chromatogram.

The content of α-tocopherol in the oil samples was determined using an HPLC (Hitachi Chromaster, Japan) equipped with a C18 column (Mightysil RP-18 GP 250–4.6, 5 µm particle size, Kanto Kagaku Co., Japan) and a UV-VIS detector (Sánchez-Machado *et al.*, 2002). Briefly, oil sample was dissolved in mobile phase (methanol-acetonitrile 30:70, v/v). A 20 µl of the mixture was injected onto the column (30°C) with a constant flow-rate of mobile phase (1.0 ml/min). The mobile phase was previously degassed by sonication for 40 min prior to HPLC analysis. The tocopherol was monitored at the wavelength of 205 nm. The α-tocopherol stock was prepared as a series of concentrations. The calibration curve was constructed with series of standard solutions and used for quantification basis of peak areas.

Analytical methods for physical properties

The viscosity measurement of the oil samples was performed using a Rheometer (Model SV-10 Brookfield, Japan). Ten milliliters of the oil were subjected to the viscosity measurement within a constant shear rate at 30°C. The spectrophotometer colorimeter (Spectrophotometer X-rite, Model SP60, USA) was used to determine color parameters (L^*, a^* and b^* values) of the oil samples. In this coordinate system, L^* value corresponds to lightness, ranging from 0 (black) to 100 (white), a^* value ranges from -100 (greenness) to +100 (redness), and b^* value ranges from -100 (blueness) to +100 (yellowness). Color development of oil sample can be expressed as total color change value (Maskan, 2006) where L^*_0, a^*_0 and b^*_0 denote as the color parameters of the unroasted oil and L^*, a^* and b^* mean the color parameters of the roasted oil (Eq. 1).

$$\text{Total color change value} = \sqrt{(L^*_0 - L^*)^2 + (a^*_0 - a^*)^2 + (b^*_0 - b^*)^2} \quad \text{Eq. 1}$$

Analytical method for thermal properties

The melting and crystallization behaviors of the oils were determined by differential scanning calorimetry (DSC, Model DSC822e, Mettler, Toledo) equipped with a refrigerated cooling system as a modified method of Liaotrakoon *et al.* (2013). To examine thermal properties, oil samples were weighed and hermetically sealed in a pan using a sample preparatory device. The time-temperature program applied was set to equilibrate at 50°C for 15 min to ensure a completely liquid state, cooling at 10°C /min to -60°C, holding at -60°C for 5 min and heating at 10°C /min to 50°C. Thermal properties were observed from the DSC thermograms using the stare evaluation version 8.10 software (Mettler, Toledo).

Statistical analysis

All analytical determinations were performed in triplicate. Values of different parameters are expressed as means ± standard deviations (SD). The significant differences among means of raw (unroasted) and roasted cashew nut oils were subjected to paired sample t-test analysis, and the confidence limits used in this study were based on 95 % ($p < 0.05$).

Results and Discussions

Characteristics of cashew nut oil as affected by roasting

The cashew nuts were roasted at two different conditions which at 150°C for 30 and at 150°C for 60 min prior to an oil cold-extraction with petroleum ether. The oil yield of cashew nuts roasted ranged from 30.67 to 31.67% which significantly higher than the yield of unroasted oil (27.33%) (Table 1). A certain amount of protein denaturation which could improve oil extractability of cashew nuts, especially at high temperature, may lead to damage of the cell membranes, resulting in the high extractability of oil (Yoshida and Kajimoto, 1994; Yoshida and Takagi, 1997; Lee *et al*., 2004; Mohamed and Awatif, 1998). In addition, roasting process also results in high amounts of oil extracted from sesame seeds (Mohamed and Awatif, 1998). The apparent viscosity of the roasted cashew nut oils was higher compared to the unroasted oil (54.2-61.0 mPa.s compared to 48.0 mPa.s). The viscosity of the oil might be depend

Table 1. Characteristics of cashew nut oil extracted under different roasting conditions

Characteristics	Cashew nut oil		
	Unroasted	Roasted at 150°C for 30 min	Roasted at 150°C for 60 min
Yield (%)	27.33 ± 0.27[a]	30.67 ± 0.25[b]	31.67 ± 0.30[c]
Physical properties			
Color parameters			
L* (lightness)	45.56 ± 0.24[a]	42.89 ± 0.32[b]	40.47 ± 0.36[c]
a* (redness)	-3.01 ± 0.02[a]	-1.14 ± 0.04[b]	0.88 ± 0.03[c]
b* (yellowness)	25.63 ± 0.30[a]	27.75 ± 0.76[b]	30.69 ± 0.98[c]
Total color change value	0.00 ± 0.00[a]	3.92 ± 0.26[b]	8.18 ± 0.74[c]
Viscosity (mPa.s)	48.0 ± 1.9[a]	54.2 ± 1.4[b]	61.0 ± 1.8[c]
Thermal properties			
Melting temperature (M,°C)			
M_1	-60.00 ± 0.00[a]	-60.00 ± 0.00[a]	-60.00 ± 0.00[a]
M_2	-48.89 ± 0.14[a]	-49.48 ± 0.08[a]	-49.72 ± 0.19[a]
M_3	-2.42 ± 0.52[a]	-2.62 ± 0.21[a]	-2.57 ± 0.32[a]
Crystallization temperature (C,°C)			
C_1	-13.77 ± 0.77[a]	-13.57 ± 0.56[a]	-13.92 ± 0.30[a]

Results shown as means ± SD (n=3). Data within rows followed by different letters are significantly different ($p < 0.05$).

on the oil temperature, the difference in saturated and unsaturated fatty acids, the degree of polymerization and the position of the hydroxyl group of the fatty acids (Akhtar *et al.*, 2009; Abramovic and Klofutar, 1998). The color parameters (L*, a* and b* values) of these three cashew nut oil samples were significantly different. The roasted cashew nut oil became browner than the unroasted oil, resulting in an increase of total color change value (from 3.92 to 8.18 compared to the unroasted oil). The increase in color development of the oils with increasing roasting time was found and may due to the formation of some browning compounds which can be referred to as Maillard reaction products at elevated roasting times. The production of Maillard reaction products occurred after thermal processing at 100°C for 15 min in some legumes and cereals (Azizah and Zainon, 1997).

The thermal properties of the cashew nut oils were analyzed by DSC. The melting and crystallization temperatures of the oils are illustrated in Table 1. The melting profile for the unroasted and roasted cashew nut oils consist of three endothermic peaks with a broader temperature range from -60°C to -2°C with the major melting peak (M_2, -48.89°C to -49.72°C). The DSC crystallization profiles of all cashew nut oils have only one exothermic peak. Theses oils crystallize at about -13°C. It can be deduced that the average crystallization and the melting temperatures of all cashew nut oil samples seem to be comparable values ($p > 0.05$).

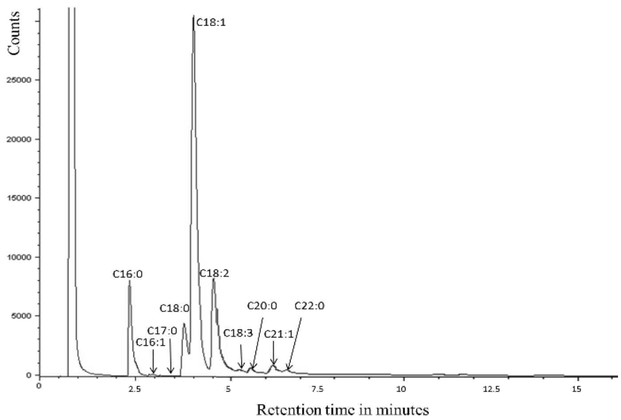

Figure 1. GC chromatogram showing fatty acid profile of extracted cashew nut oil

Influence of roasting on fatty acid composition of cashew nut oil

The fatty acid composition of an oil is significantly related to its stability, thermal properties, and nutritional value. Fatty acid profiles of the raw and roasted cashew nut oils are expressed as GC chromatogram (Figure 1), and clearly described in Table 2. Cashew nut is a high value edible nut and mainly consists of monounsaturated

Table 2. Fatty acids composition of cashew nut oil extracted under different roasting conditions

Fatty acid	Fatty acid composition g/100 g fatty acids		
	Unroasted	Roasted at 150°C for 30	Roasted at 150°C for 60
Palmitic acid (C16:0)	12.27 ± 0.04 [a]	12.35 ± 0.01 [a]	11.68 ± 0.10 [b]
Margaric acid (C17:0)	0.13 ± 0.01 [a]	0.09 ± 0.00 [b]	0.08 ± 0.00 [b]
Stearic acid (C18:0)	7.38 ± 0.04 [a]	6.42 ± 0.00 [b]	6.15 ± 0.06 [c]
Arachidic acid (C20:0)	0.17 ± 0.00 [a]	0.33 ± 0.00 [b]	0.45 ± 0.00 [c]
Behenic acid (C22:0)	0.18 ± 0.01 [a]	0.18 ± 0.00 [a]	0.17 ± 0.00 [a]
∑Saturated fatty acids	***20.12 ± 0.01 [a]***	***19.37 ± 0.01 [b]***	***18.53 ± 0.02 [c]***
Palmitoleic acid (C16:1)	0.32 ± 0.00 [a]	0.31 ± 0.00 [a]	0.36 ± 0.03 [b]
Oleic acid (C18:1)	63.21 ± 0.03 [a]	63.58 ± 0.01 [a]	63.66 ± 0.08 [a]
Heneicosanoic acid (C21:1)	0.08 ± 0.01 [a]	0.09 ± 0.00 [b]	0.10 ± 0.00 [c]
∑Monounsaturated fatty acids	***63.61 ± 0.01 [a]***	***63.98 ± 0.01 [b]***	***64.12 ± 0.02 [c]***
Linoleic acid (C18:2)	16.19 ± 0.03 [a]	16.47 ± 0.03 [b]	17.19 ± 0.05 [c]
Linolenic acid (C18:3)	0.08 ± 0.02 [a]	0.18 ± 0.00 [b]	0.16 ± 0.00 [b]
∑Polyunsaturated fatty acids	***16.27 ± 0.02 [a]***	***16.66 ± 0.02 [b]***	***17.35 ± 0.02 [c]***
Essential fatty acids (C18:2 + C18:3)	**16.27 ± 0.02 [a]**	**16.66 ± 0.02 [b]**	**17.35 ± 0.02 [c]**

Percentage of fatty acids are expressed as means ± SD (n=3). Data within rows followed by different letters are significantly different ($p < 0.05$). Bold values indicate the summation of individual classes of fatty acids.

fatty acids (roughly two-thirds of total fatty acids), followed by saturated fatty acids (18.53-20.12%) and polyunsaturated fatty acids (16.27-17.35%). The predominant monounsaturated fatty acid present in both unroasted and roasted cashew nut oils was oleic acid (C18:1), which was present at 63.61–64.12%. In the case of polyunsaturated fatty acid, linoleic acid (C18:2) was the most abundant (16.19–17.19%) with a lesser amount of linolenic acid (C18:3, < 0.18%). Palmitic acid (C16:0) and stearic acid (C18:0) were also identified as the primary saturated fatty acids in cashew nut oils which were present at 11.68-12.27% and 6.15-7.38%, respectively. The results are in good agreement with Venkatachalam and Sathe (2006), Ryan *et al.* (2006) and Toschi *et al*. (1993) for fatty acids found in raw cashew nut oil.

In general, the ratio of total saturated fatty acids to monounsaturated fatty acids and polyunsaturated fatty acids of cashew nut oils was 0.8:2.5:0.7. It might be assumed that cashew nut oil has the right combination of fatty acids composition because the fatty acid ratio is nearly to 1:2:1 which is ideal for human consumption. The relative abundance of monounsaturated fatty acids in cashew nut is conducive to the promotion of health benefits. In addition, linoleic acid is an essential fatty acid which can be used to prevent the heart and arteries diseases (Achal, 2002). The fatty acid ratio remained slightly change between raw and roasted cashew nut oils, suggesting that roasting had little effect on the fatty acid profile of the oils tested. The amount of saturated fatty acid of roasted cashew nut oil at longer time (60 min) decreased to 1.59%, whereas those of monounsaturated and polyunsaturated fatty acids increased (0.51 and 1.08%, respectively) compared to raw cashew nut oil. However, unchanged fatty acid compositions of rice germ oil (Kim *et al*., 2002), sesame seed oil (Yen, 1990; Yoshida and Takagi, 1997; Mohamed and Awatif, 1998) and safflower seed oil (Lee *et al*., 2004) prepared under different roasting temperatures and time combinations were found. This is might be due to the relatively stable and less unsaturated type of fatty acids presents in the cashew nut oil (Chandrasekara and Shahidi, 2011).

Influence of roasting on α-tocopherol of cashew nut oil

As tocopherol have been considered as potential antioxidative compounds in vegetable oils, the α-tocopherol in raw and roasted cold-pressed cashew nut oils were necessary to determined by HPLC and the results are presented in Figure 2. The reduction of

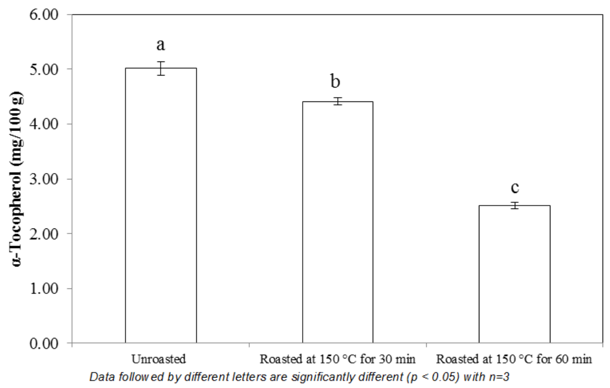

Figure 2. Content of α-tocopherol in cashew nut oils as affected by roasting

α- tocopherol clearly showed in roasted cashew nut oil and even more pronounced for roasted cashew nut oil at longer roasting time. A remarkable decreasing of α-tocopherol was observed. The α- tocopherol content of roasted cashew nut oil at 150°C for 30 min and at 150°C for 60 min deceased to 12.07 and 49.84% compared to that of raw cashew nut oil, respectively. It varied in a range of 2.52-5.02 mg/100 g oil sample. The α-tocopherol content of the present study was comparable with the results of Toschi *et al*. (1993) (2.8-8.2 mg/100 g). Normally, tocopherol decreases after roasting process due to occurrence of oxidation and polymerization during the process (Lea and Ward, 1959). Apart from tocopherol, alkyl phenols in uncooked cashew nut oil were also presented as a major of anacardic acid and cardol with a minor presence of 2-methylcardol and cardanol (Gomez-Caravaca *et al*., 2010).

Conclusion

Oils from raw and roasted cashew nuts were extracted and examined for their fatty acid composition, some physicochemical and thermal properties. A high yield of cashew nut oil was observed (27.33-31.67%). A total color change value of roasted cashew nut oil was found to be higher than raw oil, possibly due to the formation of Maillard reaction products which are known to render antioxidant effects. In general, fatty acid composition remained unchanged for both raw and roasted cashew nut oils. Oleic acid was the predominant fatty acid in all tested oil samples, followed by linoleic, palmitic and stearic acids, resulting in the comparable values of their crystallization and melting temperatures. The α-tocopherol, known as bioactive compounds in cashew nut, was also found (5 mg/100 g oil). The results indicate that the roating process has had a significant impact on the content of tocopherol, whereas has no significant effect on fatty acid profile and can improve the color development. In addition, an important phytochemical compounds presented in cashew nut oils such as monounsaturated fatty acids and tocopherol is associated with many health benefits.

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