**International Journal of Food Science and Nutrition**
**ISSN: 2455-4898**
**Impact Factor: RJIF 5.14**
**www.foodsciencejournal.com**
**Volume 2; Issue 6; November 2017; Page No. 122-128**

# Antioxidant and physicochemical properties of oils extracted from cashew (*Anacardium occidentale* L.) Kernels

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**Abstract**
The effects of various processing methods such as hand cracking (HC), steam cooking (SC), oil roasting (OR) and dry roasting (DR) on the antioxidant and physicochemical properties of cashew kernel oil samples were investigated. Results revealed that OR produced the highest percentage of wholesome kernels (93.00%) while a gradual decrease was observed from DR (61.30%), SC (33.18%) to HC (10.00%) methods. Percentage yield of the oil samples from solvent extraction and screw press methods showed high values in the DR (44.10 and 32.81%) followed by OR (39.80 and 30.90%), HC 35.18% and 28.24% and SC (34.40% to 27.06%), respectively. Total phenolic (53.18mgGAE/g), total flavonoid (24.07mgRE/g) and total antioxidant capacity (12.50mgAAE/g) of the DR oil sample drastically reduced than other processing methods studied. Physicochemical analyses showed that peroxide values were 0.33, 0.43, 0.62 and 0.84meq/g for SC, HC, OR and DR, respectively with significant difference ($P<0.05$) in all the samples. Moisture, impurities and volatile matter (MIV) values decreased in the following order; 0.39% (SC), 0.33% (HC), 0.18% (OR) and finally 0.16% for DR sample. Flash (290ºC) and smoke (218ºC) points of the oil was highest in the OR and decreased to 273ºC and 210ºC in the DR sample, respectively. Processing methods showed no significant effect on the iodine and saponification values, specific gravity, melting and cloud points of the oil samples. Based on the values for antioxidant, physicochemical, wholesomeness and oil yield, the findings of this study has shown that DR and OR methods can be recommended at the industrial and domestic level for the processing of cashew kernel oil.

**Keywords:** antioxidant properties, cashew kernel oil, processing methods, physicochemical properties

## 1. Introduction

Cashew kernel as a good source of vegetable oil has been recognized greatly in many parts of the world today and it has found great use in domestic cooking and pharmaceutics (Ojeh, 1985) [23]. Extracted from the mesocarp of the nut, cashew kernel has the right combination of fatty acids. The ratio of saturated to monounsaturated and polyunsaturated fatty acid of cashew kernel oil is 1:2:1 which is essential for growth, development as well as prevention of coronary artery disease, hypertension, arthritis, inflammatory and autoimmune disorder (Wang and Jones, 2004) [29]. According to Achal (2005) [1], the relative abundance of monounsaturated fatty acids in cashew kernel oil is conducive to promotion of good health and poses no nutritional risk.

The processing of cashew kernel oil is mainly carried out by small and medium scale farmers and not yet commercially in Nigeria (Akinhanmi *et al*., 2008) [3]. Its processing had always posed a problem for the oil processor due to the cashew nut shell liquid (CNSL). The CNSL contains a high percentage of phenolic compounds which is corrosive to the skin (Winterhatter *et al*., 1991) [31]. The kernels are sometimes removed from the shell by a process known as shelling, which can be achieved by various methods such as dry roasting, steam-bath roasting and oil-bath roasting. These different methods can directly affect the quality of the extracted oil and it is of economic interest to improve the oil extracted from the abundant cashew nuts for possible consumption as vegetable oil.

Processing parameters such as moisture content, heat, temperature, oxygen as well as methods and conditions of pre-shelling treatment and nut size reduction are found to have a great influence on the quality of many vegetable oils produced. Adequate processing of these oils is necessary in order to obtain and retain maximum nutritional benefits from them (Singh *et al.*, 2007) [26]. During processing, oil characteristics such as colour, flavour, fatty acid profile and bioactive compounds are shown to be altered especially during dry roasting method (Jennifer *et al*., 2010, Raheem *et al.*, 2015) [17, 25]. During the conventional shelling processes in cashew, the cashew nut samples are exposed to extremely high levels of temperature (ranging from 75 to 150ºC) which may affect the heat sensitive bioactive compounds thereby altering the quality of the extracted oil.

From the foregoing, it is evident that there is need to study the effects of different processing methods on the quality of cashew kernels, antioxidant and physicochemical properties of the extracted oil samples so as to ultimately determine optimum conditions for the processing of cashew kernel oil for various commercial applications.

## 2. Materials and Method

### 2.1 Sample Collection and Treatment

Four kilograms (4kg) of cashew nut samples were collected from Diffin's farm in Ijokom village, Mfuma, Yala Local Government area of Cross River State, Nigeria. The collected samples were cleaned to remove any foreign matter and then sundried for three days to prevent deterioration during storage. They were conditioned (mild spraying with water in a sieve) to increase flexibility and prevent scorching during the roasting process. They were then divided into four batches (900g each), introduced to different processing methods and all regents used were of analytical grade and obtained from the Department of Food Science and Technology Laboratory, Rivers State University, Port Harcourt, Nigeria.

## 2.2 Processing Methods of Cashew Kernel

### 2.2.1 Hand Cracking Method

The conditioned nuts were left untreated, cracked manually by using a wooden hammer, but not dried. Hand gloves were worn on the hands to prevent contact with the Cashew nut shell liquid (CNSL).

### 2.2.2 Steam Cooking

The steam roasting of cashew nut samples was performed as described by Jain *et al.*, (2004) with some modifications. In this method, the conditioned nuts were steamed in a steam cooker and processed for 15min. Subsequently the steamed boiled cashew nuts were cooled to room temperature, cracked using a wooden mallet to get the kernels.

### 2.2.3 Oil Roasting Method

The conditioned nuts were placed in a metal basket and immersed in a pot of hot vegetable oil (groundnut oil) for 1 min to make the shell brittle. The nuts were stirred at intervals of 10 sec to prevent burning while in the hot oil. The cashew nut shell liquid of the nut was extracted into the pot as the volume of the oil increased in the pot. The cashew nuts were then poured out after 1 min and allowed to cool for about 1h. The brittle shell was broken with wooden mallet and the kernel extracted as described by Emelike and Ebere (2015) [10].

### 2.2.4 Dry Roasting

Pot was placed on a basic earth fire place and then the cashew samples were turned into the pot and roasted for 2min. The heat caused the withdrawal of CNSL, which led to ignition of cashew samples. After 2min, the cashew nuts were removed from the fire, slowly cooled to room temperature (30±2ºC) and cracked with wooden hammers to obtain the kernels as described by Mandal (1992) [19].

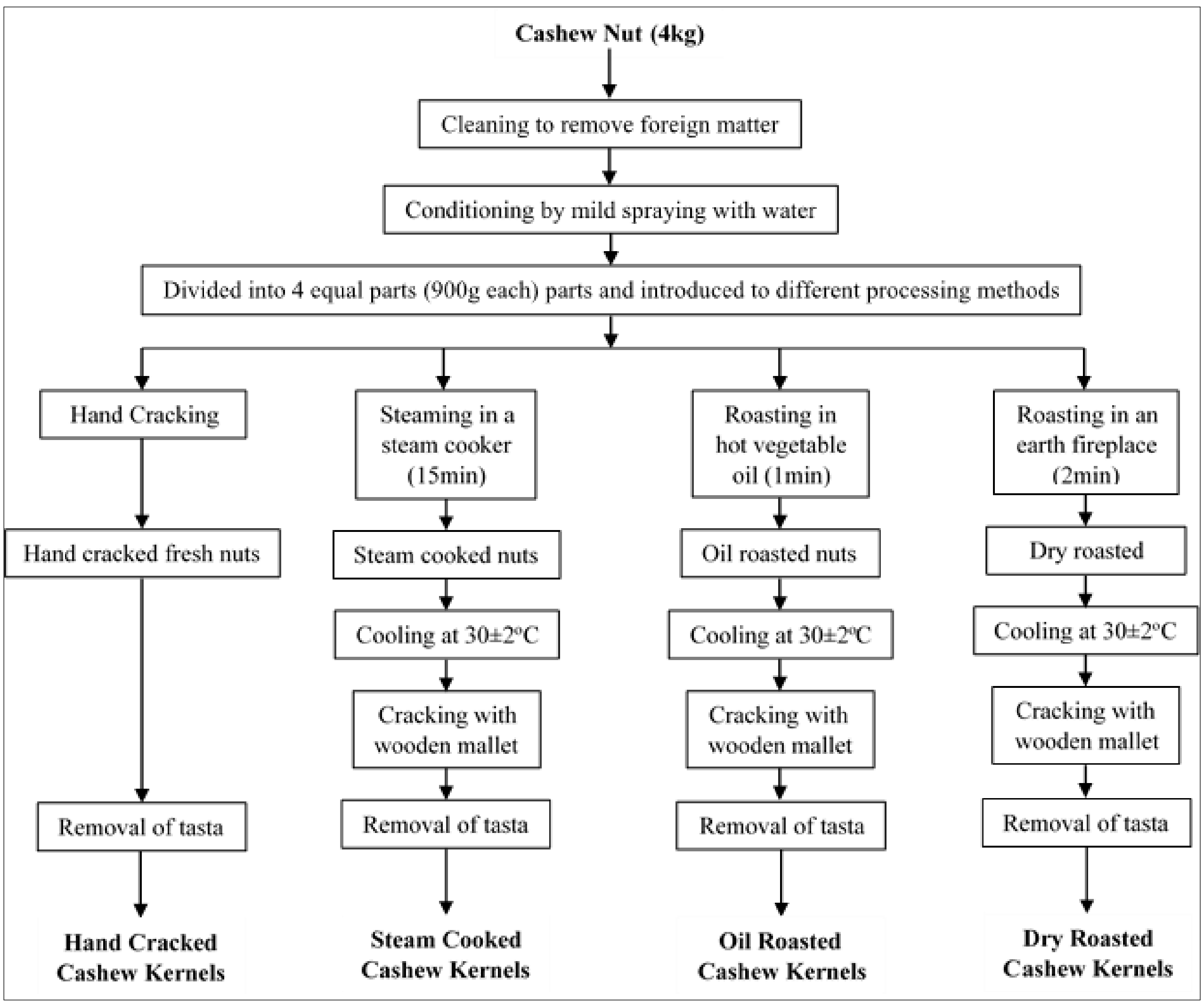



**Fig 1:** Flow chart showing different processing methods of cashew kernel

### 2.3 Percentage Damage and Wholesome Kernels

About 500g of kernels was weighed. The whole and broken kernels were sorted, weighed and calculated using the formula below;

$$\% \, Damage \, kernels = \frac{Weight \, of \, Damaged \, Kernels}{Weight \, of \, Cashew \, Kernels} \, x \, \frac{100}{1}$$

$$\% \, Whole \, kernels = \frac{Weight \, of \, Whole \, Kernels}{Weight \, of \, Cashew \, Kernels} \, x \, \frac{100}{1}$$

### 2.4 Oil extraction from processed cashew kernels

Different processed cashew kernel samples were milled separately into powered form using Philips HR200 Blender and set outside. Solvent extraction and screw press methods were used to extract oil from the milled cashew kernel samples. Five hundred (500g) of milled cashew kernels were cooked with steam in a steam cooker for 15min. They were divided into two equal parts (250g each) for easy processing. They were introduced into a screw press system simultaneously and the oil was obtained through the pressure exerted on the steam cooked cashew kernel flour.

The next was solvent extraction method which was done in duplicates using petroleum ether which is normally used in the extraction of plant kernel oil. The oil extraction was done in small quantities of 20g of milled cashew kernel and the extraction was allowed for 6h at 60ºC in a soxhlet-extractor with 200ml solvent and the oil was separated by evaporation. Percentage yield of the extracted oil samples was further calculated using the below equation;

$$\% \, Yield \, of \, Oil = \frac{Weight \, of \, Extracted \, Oil}{Weight \, of \, Kernels \, Used} \, x \, \frac{100}{1}$$

### 2.5 Antioxidant properties of cashew kernel oil samples

#### 2.5.1 Estimation of total phenol content

The total phenolic content of the extract was determined by the Folin–Ciocalteu reagent (FCR) according the procedure reported by (Kaur and Kapoor, 2002) [18] with some modifications. Two hundred (200 µL) of extract (1 mg/mL) were made up to 3 mL with distilled water, mixed thoroughly with 0.5 mL of Folin–Ciocalteu reagent for 3 min, followed by the addition of 2 mL of 20% (w/v) sodium carbonate. The mixture was then incubated at room temperature (30±2ºC) for 60 min and absorbance was measured at 700nm using uv/vis Spectrophotometer (USA). The total phenolic content was calculated from the calibration curve and the results were expressed as mg of gallic acid equivalent per milligrams of oil (mgGAE/g oil).

#### 2.5.2 Estimation of total flavonoid content

Total flavonoid of the oil samples was determined by aluminum trichloride colorimetric method using rutin as standard (Nile and Khobragade, 2010) [22]. This method is based on the formation of a flavonoid-aluminum complex. The oil sample (0.1ml) in methanol (100µgml$^{-1}$) was mixed with 0.2ml of 5% sodium nitrate. It was allowed to react for 5min after which 0.2ml aluminum trichloride in methanol (10%) and 1ml of sodium hydroxide (1M) was added. The mixture was allowed to stand at room temperature (30±2ºC) for 15min and the absorbance read at 510nm against reagent blank. The amount of flavonoid was calculated from rutin equivalent per gram of sample (mgREg$^{-1}$) which was calculated using the formula, $y = 0.009\,x - 0.001$, where, $y$ is the absorbance at 510nm and $x$ is the amount of rutin equivalent (mg/mL).

#### 2.5.3 Total Antioxidant Capacity

The total antioxidant capacity was evaluated by phosphomolybdenum method as described by Nabasree and Bratati (2007) [21]. The assay is based on the reduction of MO (VI) to MO (V) by complex at acidity pH. The sample solution in ethanol (0.3ml: 100µgml$^{-1}$) was mixed in reagent solution (3ml: 0.6M sulphuric acid, 28Mm sodium phosphate monobasic and 4Mm ammonium molybdate). A blank composed of 3ml of reagent solution and methanol was prepared. The sample mixture in test tubes were capped and incubated in boiling water bath at 95ºC for 90min. The absorbance of the samples was read against reagent blank at 695nm. The antioxidant capacities of sample was expressed as mg ascorbic acid equivalent per gram of sample (mg AAEg$^{-1}$) which was calculated using the formula, $y = 0.002\,x - 0.001$, where, $y$ is the absorbance at 695 nm and $x$ is the amount of ascorbic acid equivalent (mg/mL).

### 2.6 Physicochemical Analysis of the Oil Samples

Acid, iodine, saponification and peroxide values were determined by titration using AOAC (2012) [5] method. Specific gravity, free fatty acid, melting point, cloud point, smoke point, flash point, moisture, impurities and volatile matter (M.I.V) were all determined using the AOCS, 2009 [6] method.

### 2.7 Statistical Analysis

Analyses were carried out in triplicate of each set up. Data obtained were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Science (SPSS Inc, Chicago) V20.0 software, year 2011. Differences between means were evaluated using Duncan New Multiple Range Test and significance accepted at 5% level of probability according to the method of Wahua (1999) [28].

## 3. Results and Discussion

### 3.1 Influence of processing methods on the kernels (Wholesome and Damaged)

The result showed that wholesome kernels ranged from 10.00 – 93.00% with hand cracked (HC) and oil roasted (OR) kernels having the lower and higher percentages, respectively while reverse was the case for damaged kernels ranging from 7.00 – 90.00% (OR and HC, respectively) as shown in Table 1. This may be attributed to the fact that the kernels during processing were all immersed fully in the oil with uniform temperature which aids the easy remover of the shell without breakage while hand cracking resulted to more breakage as heat was not applied and the shell was not brittle to the crack. The dry-roasting process resulted in slight reduction in the damaged kernels but not as compared with the oil-bath roasting (38.71 and 7.00%, respectively). This may be due to lack of uniformity in the heat temperature applied during dry roasting technique. Hence, it brought about overheating of some nuts resulting to damage and charring in the fire. These results is an indication that the oil and dry roasting methods will be desirable for marketing purposes since consumers will want wholesome kernels while producers desires best method(s) to produce wholesome kernels in order to increase profitability.

**Table1:** Percentage damage and wholesome kernels

| Processing method | % Wholesome | % Damaged |
|---|---|---|
| Hand cracking | 10.00 | 90.00 |
| Steam cooking | 33.18 | 66.82 |
| Oil roasting | 93.00 | 7.00 |
| Dry roasting | 61.30 | 38.71 |

Results were Mean Values of Triplicate Determinations

### 3.2 Influence of processing methods on the yield of cashew kernel oils

The effect of processing methods on the yield of cashew kernel oil samples is shown in Table 2. The dry roasting produced significantly ($p<0.05$) higher oil yield (44.10%) than other processing methods (39.80%, 35.14% and 34.40% for OR, HC and SC, respectively) of oil samples extracted using solvent method. This trend was also observed in the percentage yield of oil samples processed using screw press method (32.81, 30.90, 28.24 and 27.06 for DR, OR, HC and SC, respectively). This high yield might be due to decreased moisture content as a result of direct action of fire which caused the scorching of the nuts. This prediction is in agreement with the statement of Abidakun *et al.*, (2012) [2] who stated that oil yield increases as moisture content of the oil decreases. In addition, dry roasting process also resulted in high amounts of oil extracted from sesame seeds (Mohammed and Awatif, 1998) [20]. This implies that higher moisture content means lower oil yield. Akinoso *et al.*, (2006) [4] reported that moisture content has highest influence on sesame oil yield. The increase yield is also probably due to the fact that drying at high temperature helps in the removal of more bound water from the product (Rozis, 1997) [24] and this also aid the extraction of oil as the product becomes dry and extraction of oil is enhanced. This is evident in this research as oil yield of steamed cooked cashew kernel was the lowest in both oils extracted via solvent and screw press methods (34.40 and 27.06%), respectively which could have resulted through the incorporation of more moisture during the steaming process. This implies that dry and oil roasting methods are the best techniques to be employed to ensure high percentage of oil yield consecutively.

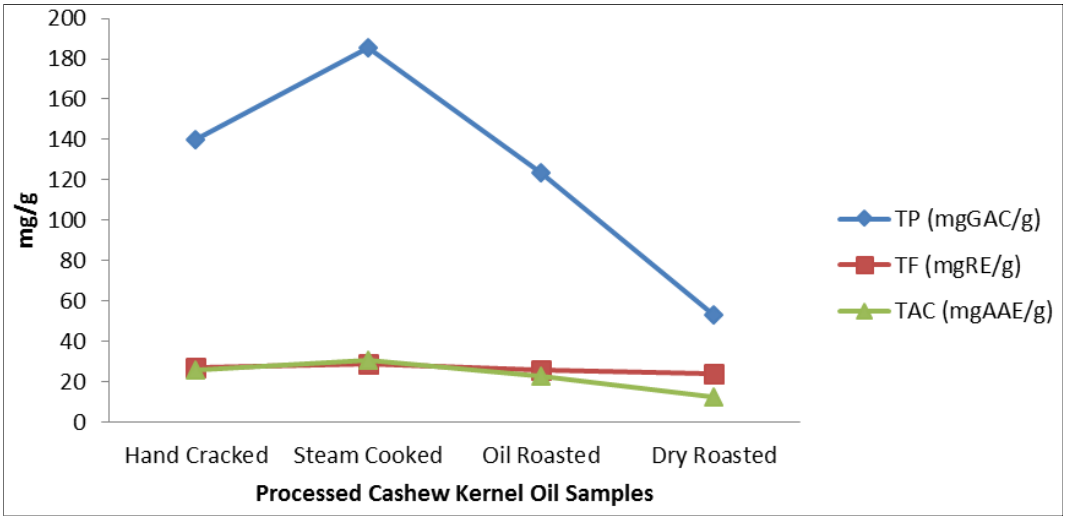
**Table 2:** Oil Yield of Cashew Kernel Oils Extracted from Different Methods

| Processing method | Solvent extraction yield (%) | Screw press yield (%) |
|---|---|---|
| Hand cracking | $35.14{\pm}0.23^{c}$ | $28.24{\pm}0.59^{c}$ |
| Steam cooking | $34.40{\pm}0.45^{d}$ | $27.06{\pm}0.65^{d}$ |
| Oil roasting | $39.80{\pm}0.18^{b}$ | $30.90{\pm}1.01^{b}$ |
| Dry roasting | $44.10{\pm}1.39^{a}$ | $32.81{\pm}1.12^{a}$ |
| L.S.D | 2.67 | 2.14 |

$^{a-d}$ Means having the same superscript within the column are not significantly different ($P<0.05$)
± Standard deviation of triplicate determinations

### 3.3 Antioxidant Properties

Steam cooking (SC) method was found to possess highest antioxidant values of 185.30mgGAE/g$^{-1}$, 28.59mgREg$^{-1}$ and 30.75 mgAAEg$^{-1}$ for total phenol, total flavonoid and total antioxidant capacity, respectively while DR method had the least antioxidant values (53.18 mgGAE/g$^{-1}$, 24.07 mgREg$^{-1}$ and 12.50 mgAAEg$^{-1}$) for total phenol, total flavonoid and total antioxidant capacity, respectively as presented in Figure 1. Hand Cracking (HC) method produces antioxidant values of 139.73 mgGAE/g$^{-1}$, 27.18 mgREg$^{-1}$ and 225.50 mgAAEg$^{-1}$ for total phenol, total flavonoid and total antioxidant capacity, respectively while OR samples showed similar trend from total phenol to total antioxidant capacity with values of 123.47mgGAE/g$^{-1}$, 25.52 mgREg$^{-1}$ and 23.00 mgAAEg$^{-1}$, respectively. The decrease in antioxidant compounds in the dry and oil roasted cashew kernel oil samples could be as a result of the exposure of the nuts to light from the fire, temperature, heat and oxygen during processing. This correlates with reports of Etsuji *et al.*, (1978) [11] that antioxidant properties decrease as roasting temperature increases. Fillion and Henry (1998) [12] also stated that antioxidants and vitamins are often lost due to oxidation. Steam cooking method resulted in a significant retention of antioxidants than other treatments. This may be due to the moist heating process and less exposure to oxygen. Steam treatments have been shown to result in a greater retention of antioxidants compared to other treatments (Xu and Chang, 2008) [7]. Steaming has also retained phenolic compounds with antioxidant properties significantly better than other processing techniques (Vallejo, 2003) [27]. The oil-roasting process resulted in a mild loss in these properties. This could also be attributed to oxygen during frying in oil process. Gordon and Kourimska (1995) [13] reported that the content of α-tocopherol was lost more quickly than other tocopherols of canola oil with a 50% reduction after 4-5 frying operations.




**Key:** TP = Total Phenol, TF = Total Flavonoid and TAC = Total Antioxidant Capacity.
**Measurements:** GAE = Gallic acid equivalent, RE = Rutin equivalent and AAE = Ascorbic acid equivalent.

**Fig 2:** Antioxidant Properties of Cashew Kernel Oil Samples

### 3.4 Physicochemical properties of cashew kernel oils

Physicochemical analysis carried out on the cashew kernel oil samples showed that acid values obtained were 1.83mg/g, 1.63mg/g, 1.45mg/g and 1.17mg/g for SC, HC, OR and DR processing methods, respectively and they were not significantly different (P<0.05) from each other as expressed in Table 3. Iodine values also showed that there was no significant difference (P<0.05) in all the processing methods analyzed. Iodine values obtained from SC, HC, OR and DR process were 44.31, 44.58, 44.36 and 44.13mgKOH/g, respectively. Saponification values obtained from SC, OR, DR and HC methods were 201.5, 201.6, 201.2 and 201.3mg/g, respectively with no significant difference (P<0.05) in all the samples. Peroxide values increased to the highest in the dry roasted samples (0.84mg/g) and decreased to the least in the steam cooked samples (0.33mg/g); hence, showed significant difference (P<0.05) in all the samples. The increase and decrease in peroxide values of the oil samples may be due to the oxidation process. The oxidation of oil can often take place when oil, oxygen and catalyst are in contact. A high oxygen level in the dry roasting atmosphere might cause a faster and more complete oxidation than the oil roasting process. This report agrees with that of Etsuji *et al.*, (1978) [11] that dry roasted peanuts oxidized very rapidly since roasting in fire comes from a chemical reaction between oxygen in the atmosphere and the wood used. Also, oils from safflower seeds roasted without a carrier at 180$^oC$ for a longer time resulted to much greater peroxide values than oils from unroasted safflower seeds. When food is immersed in hot oil in the presence of oxygen, the oil is exposed to water from the food which causes hydrolytic changes. The contact between the oxygen and the food equally causes oxidative changes from the surface to inside of the food and finally the high temperature also causes thermal changes such as isomerization, formation of aldehydes, ketones and degradation of products such as epoxides and hydroperoxides (Warner *et al.*, 1999) [30]. The steam cooked and hand cracked cashew kernel oil samples which showed a reduction in peroxide values could be as a result of their oxidation process. Kyari (2008) [14] stated that a high peroxide value is an indication of high levels of oxidative rancidity of oils which suggests low levels of antioxidant properties. This statement is in affirmation of the values obtained from antioxidant and peroxide analyses in this research.

Moisture, impurities and volatile matter (MIV) ranged from 0.16 – 0.39% with dry roasting being the lowest and steam cooking having higher value, respectively. Roasting without any carrier (oil or water) has been shown to reduce the moisture content of oil seeds than other thermal processing methods owing to the dry roasting technique where nuts are roasted without immersing in a liquid (Abidakun *et al*., 2012) [2]. The MIV content of oils produced from oil roasting method compares well with that of dry roasting method with no significant difference (P<0.05) owing to the oil used in frying the nuts. Frying in oil reduces water activity on the surface of the food (Fillion and Henry, 1998) [12]. MIV values observed in this study were within the standard limits for safe moisture (0.2%) content of seed oils according to the CODEX (1999) [8]. The MIV content oils obtained from two processing techniques (dry and oil roasting) also decreased within the standard limits as a result of the level of temperature used. This interlined with the statement of Rozis (1997) [24] that high temperature helps in the removal of more bound water from the product. The reduction in moisture values is an indication that cashew kernel oils can be stored for a longer time without it going rancid (Emelike and Ebere, 2016). The presence of moisture can bring about faster decomposition of food materials. Results for specific gravity of the oil samples were 0.913, 0.910, 0.909, and 0.908 for HC, SC, DR and OR methods, respectively. Free fatty acid (FFA) showed that there was a significant difference (P<0.05) in the processing methods with SC method having higher value (0.93mg/g) than DR method with least free fatty acid (0.63mg/g). Hand cracked cashew kernel oil sample showed higher value (0.82mg/g) for the FFA as compared with the OR method (0.73mg/g). Highly significant reduction of free fatty acid could be associated with the level of moisture present. Low moisture decreases the free fatty acid content while high moisture led to its increase (Dunford and King, 2001) [9]. Increase in the acid value can be directly traced to the increase in FFA which is favoured by higher moisture content leading to high lipolytic activities by enzymes and microorganisms (Hoseney, 1994) [15]. The analyses showed that melting point and cloud point had the same values in all processing methods studied (32ºC and 2.5ºC, respectively). Flash point temperatures obtained were 280ºC, 285ºC, 290ºC and 273ºC for HC, SC, DR and OR methods while smoke point temperatures obtained were 205ºC, 195ºC, 218ºC and 210ºC for HC, SC, DR and OR processing methods, respectively. Flash and Smoke point of the oil from steam cooked samples decreased while that of dry roasted increased as a result to their moisture content.

**Table 3:** Physicochemical properties of differently processed cashew kernel oil

| Parameters | Processing Methods | | | | LSD |
|---|---|---|---|---|---|
| | Hand Cracking | Steam Cooking | Oil Roasting | Dry Roasting | |
| Acid value (mg/g) | 1.63±0.08$^{b}$ | 1.83±0.04$^{a}$ | 1.45±0.05$^{c}$ | 1.17±0.03$^{d}$ | 0.06 |
| Iodine value (mgKOH/g) | 44.58±0.50$^{a}$ | 44.31±0.30$^{a}$ | 44.36±0.39$^{a}$ | 44.13±0.20$^{a}$ | 0.66 |
| Saponification value (mg/g) | 201.3±0.25$^{a}$ | 201.5±0.10$^{a}$ | 201.6±0.05$^{a}$ | 201.2±0.05$^{a}$ | 0.43 |
| Peroxide value (mg/g) | 0.43±0.04$^{c}$ | 0.33±0.05$^{d}$ | 0.62±0.04$^{b}$ | 0.84±0.05$^{a}$ | 0.23 |
| MIV (%) | 0.33±0.11$^{a}$ | 0.39±0.02$^{a}$ | 0.18±0.04$^{b}$ | 0.16±0.06$^{b}$ | 0.17 |
| Specific gravity (g/dm3) | 0.913±0.26$^{a}$ | 0.910±0.24$^{a}$ | 0.908± 0.03$^{a}$ | 0.909±0.09$^{a}$ | 0.28 |
| Free fatty acid (mg/g) | 0.82±0.06$^{b}$ | 0.93±0.06$^{a}$ | 0.73±0.05$^{c}$ | 0.63±0.03$^{d}$ | 0.04 |
| Melting point(ºC) | 32 | 32 | 32 | 32 | |
| Cloud point(ºC) | 2.5 | 2.5 | 2.5 | 2.5 | |
| Flash point(ºC) | 280 | 285 | 290 | 273 | |
| Smoke point(ºC) | 205 | 195 | 218 | 210 | |

$^{a-d}$ Means having the same superscript within the row are not significantly different (P<0.05)
± standard deviation of triplicate determinations.
**Key:** MIV= Moisture, Impurities and Volatile matter

## 4. Conclusion

This study indicates that oil and dry roasting methods are the best processing techniques to be employed to ensure that high percentage of wholesome cashew kernels are produced. Same two methods gave raise to high yield of cashew kernel oil extracted using solvent and screw press extraction methods as compare to hand cracked and steam cooked methods studied. Among the various processing methods analyzed, dry roasting process exhibited a drastic level of reduction of antioxidant compounds in cashew kernel oil due to the increased rate of oxidation and therefore represents an approved method. Oil roasting method equally led to mild losses in antioxidant compounds and the reduction of free fatty acid as well as moisture content is an indication that good quality oil was produced using this method.

## 5. References

1. Achal E. Cashew: Nutritional and Medicinal Value of Cashew. Colarado State University press. 2005, 159-165.
2. Abidakun OA, Koya OA, Ajayi OO. Effect of Expression Conditions on the Yield of Dika Nut (*Irvingia gabonesis*) Oil under Uniaxial Compression. In Proceeding of International Conference on Clean Technology and Engineering Management (ICCEM 2012), 12th-15th Ed., Mechanical Engineering, Covenant University, Ota, Nigeria. 2012, 315-320.
3. Akinhanmi TF, Atasie VN, Akuntokun PO. Chemical composition and physicochemical properties of cashew nut (*Anacardium occidentale*) oil and cashew nut shell liquid. Journal of Agriculture, Food and Environmental Sciences. 2008; 2(1):1-10.
4. Akinoso R, Igbeka JC, Olayanju TMA. Process optimization of oil expression from sesame seed (*Sesamum indicum Linn*). Agricultural Engineering International: the CIGR Ejournal Manuscript FP. 2006; 8:6-11.
5. AOAC. Official Methods of Analysis of the Association of Official Analytical Chemists, 20th ed. Gaithersburg, M.D, U.S.A. 2012.
6. AOCS. American Oil Chemists' Society. Official Methods and Recommended Practices, 6 Ed. Champaign. 2009, 1200.
7. Xu B, Chang SK. Effect of soaking, boiling and steaming on total phenolic content and antioxidant activities of cool season food legumes. Food chemistry. 2008; 110(1):1-13. Doi: 10.1016/j.foodchem.2008.01.045.
8. CODEX. Codex Alimentarius Commission, Codex Standard for Named Vegetable Oils, CODEX-STAN 210. Agriculture and Consumer Protection. 1999; 8:12-22.
9. Dunford NT, King JW. Thermal gradient deacidification of crude rice bran oil utilizing supercritical carbon dioxide. Journal of the American Oil Chemists' Society. 2001; 78(2):121-125.
10. Emelike NJT, Ebere CO. Influence of processing methods on the tannin content and quality characteristics of cashew by-products. Agriculture and Food Sciences Research. 2015; 2(2):56-61.
11. Etsuji Y, Kyozo M, Yukihiro I. Oxidative deterioration of roasted peanuts. Japanese Society for Food Science and Technology. 1978; 25(5):293-301. Doi.org/10.3136/nskkk1962.25.293.
12. Fillion L, Henry CJK. Nutrient losses and gains during frying: a review. International Journal of Food Sciences and Nutrition. 1998; 49(2):157-168. Doi.org/10.3109/09637489809089395.
13. Gordon MH, Kourimska L. The effect of antioxidants on changes in oils during heating and deep frying. Journal of the Science of Food and Agriculture. 1995; 68:347-353.

14. Kyari MZ. Extraction and characterization of seed oils. International Agrophysics. 2008; 22:139-142.
15. Hoseney RC. Principal of Cereal Science and Technology. American Association of Cereal Chemistry, 2nd ed. Inc. St. Paul, Minnesota, U.S.A. 1994, 127-140.
16. Jain SK, Powar AG, Kad VP, Dandekar SR, Salvi DA, Dekale JS. Effect of direct steam roasting on organoleptic properties of cashew-nut kernels. Cashew. 2004; 18:20-24. 610.
17. Jennifer T, Vellingiri V, Walter V, Wolfgang S, Veronika S, Ute G *et al*. Bioactive compounds in cashew nut (*Anacardium occidentale L.*) kernels: effect of different shelling methods. Journal of Agricultural and Food chemistry. 2010; 58(9):5341-5346. Doi: 10.1021/jf904580k.
18. Kaur C, Kapoor HC. Anti-oxidant activity and total phenolic content of some Asian vegetables. International Journal of Food Science and Technology. 2002; 37(2):153-161. DOI: 10.1046/j.1365-2621.2002.00552.x
19. Mandal RC. Cashew Production and Processing Technology. In: Singh R.P and Srivastava P, Eds. Post-Harvest Processing of Food Grains, Agro-Botanical Publishers, India. 1992, 146-148.
20. Mohamed HMA, Awatif II. The use of sesame oil unsaponifiable matter as a natural antioxidant. Food Chemistry. 1998; 62:269-276.
21. Nabasree D, Bratati D. Antioxidant activity of some leafy vegetables of India: A comparative study. Food Chemistry. 2007; 101:471-474.
22. Nile SH, Khobragade CN. Antioxidant activity and flavonoid derivatives of *Plumbago zeylanica*. Journal of Natural Products. 2010; 3:130-133.
23. Ojeh O. Cashew kernel – Another locally available source of vegetable oil. Nigerian Agricultural Journal. 1985; 19(20):50-56.
24. Rozis. Drying Foodstuffs. Techniques, Process and Equipment Technical Guide Book. Leiden Backhuy’s. 1997, 12-35.
25. Raheem T, Oladele E, Amoo I. Effect of roasting on some physicochemical and antimicrobial properties of cashew nut (*Anacardium occidentale*) oil. International Journal of Science and Technology. 2015; 4(12):555-559.
26. Singh B, Sekhon KS, Singh N. Effects of moisture, temperature and level of pea grits on extrusion behaviour and product characteristics of rice. Food Chemistry. 2007; 100(1):198-202.
27. Vallejo F, Tomás-Barberón FA, García-Viguera C. Phenolic compound contents in edible parts of broccoli inflorescences after domestic cooking. Journal of the Science of Food and Agriculture. 2003; 83(14):1511-1516.
28. Wahua TAT. Applied Statistics for Scientific Studies. African Link Press, Aba, Nigeria. 1999.
29. Wang YW, Jones PJ. Conjugated linoleic acid and obesity control, efficacy and mechanism. International Journal of Obesity. 2004; 28(8):941-955. Doi: 10.1038/sj.ijo.0802641.
30. Warner K, Orr P, Glynn M. Effect of fatty acid composition of oils on flavor and stability of fried foods. Journal of the American Oil Chemists' Society. 1999; 74(4):347-356.
31. Winterhatter P, Mearse H, Dekker ED. Fruits and Volatile Compounds in Foods and Beverages. New York. 1991, 389-401.