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IMPACT OF SALTING, ROASTING AND ARABIC GUM COATING WITH OR WITHOUT ANTIOXIDANTS ON THE OXIDATIVE STABILITY OF CASHEW NUTS DURING STORAGE

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ABSTRACT

In recent years, cashew nuts have received special attention because of its potential role in preventing cardiovascular disease. However, cashew nuts are very rich in total fat (48 wt. %) that can potentially be oxidized during storage. The present study was conducted to evaluate the impact of salting, roasting and Arabic gum coating with or without antioxidants on the oxidative stability of cashew nuts during Storage. Cashew samples were roasted (RCC-G) and salted (RCC-G-S) and coated with Arabic gum, and further treated with 150 ppm BHT (RCC-G-BHT) 150 ppm rosemary commercial extract (RCC-G-Rose) or a combination of both (RCC-G-BHT-Rose). Raw cashew nuts (C) and uncoated roasted cashew (URC) were used as control. All samples were analyzed for free fatty acids percentage (FFA %), peroxide value (PV), p-Anisidine value (pAV) and totox value (TV) at storage time interval from 1 to 10 months at room temperature. In the first four months, no considerable FFA%, PV, pAV or TV was detected in all samples. At the 10th month of storage, the FFA% of raw cashew (C) had the highest significant ($p < 0.05$) value, followed by roasted uncoated (URC) compared with other samples. The PV of RCC-G-BHT, RCC-G-BHT-Rose and RCC-G-Rose samples was the lowest compared with other samples with 1.09, 2.64 and 3.23 meqO2/kg at the 10th month of storage time, which indicate the high efficacy of BHT and rosemary with Arabic gum coat as antioxidant in cashew. The secondary products resulted from peroxide radical degradation, as measured by pVA, become significant after the 6th month of storage. Roasting of cashew was found to increase the PVA value in all samples. Treatment of cashew with BHT and rosemary, independently, had significantly lowered the pVA compared with other treatment with values of 1.29 and 2.16, respectively. However, treatment with a mixture of BHT and rosemary had a value of 2.9, which could be explicated by antagonistic antioxidant effect between the two. Furthermore, salting of cashew had significantly increase PV, PVA and totox values compared with all other samples after the 6th month of storage

KEYWORDS: *Peroxide Values; P-Anisidine Values; Totox Values; BHT; Rosemary; Cashew Nuts.*

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INTRODUCTION

Cashew nut (Anacardiumoccidentale L.) belongs to the Anacardiaceous family and is a fruit of an evergreen tree, native from northeast region of Brazil, which expanded spontaneously in South American countries. Cashew kernels are regarded as a worldwide nutritious food that is consumed as a nut after roasting (Lawrence 1982, Ahmed and Birnin-Yauri 2008, Asogwa, Hammed et al. 2008, Gómez-Caravaca, Verardo et al. 2010). Cashew is composed of 11- 22 % protein, 39-49 %

fat, 25% NFE, 3.8% moisture and 2.4 % ash. The mean energy content of cashew is very high and estimated to be 2525 kJ/100g (Lawrence 1982, Rico, Bulló et al. 2016). These nutrition values vary with planting conditions. Fat is the major component and is composed of 79.7% unsaturated fatty acids (FA), 20.1% saturated FA, and 0.2% Trans FA. Cashew contains many minerals with average sodium content of 144 mg/kg. Fourteen FAs were identified, among which oleic acid is the most abundant with a contribution of 60.7% to the total fat, followed by linoleic (17.77%), palmitic (10.2%), and stearic (8.93%) acids (Lawrence 1982, Rico, Bulló et al. 2016). Nuts also contain high level of mono and polyunsaturated fatty acids, vitamins, minerals, amino acids, phytosterols and generous content of fiber (Tufail, Saeed et al. 2019).

Cashew has antioxidant capacity, due to the fact that cashew nuts have bioactive compounds such as beta carotene, lutein, zeaxanthin, alpha-tocopherol, gama-tocopherol, thiamin, stearic acid, oleic acid and linoleic acid (Trox, Vadivel et al. 2010). Cashews nuts also have alkyl phenols antioxidants such as anacardic acids (Medeiros-Linard, da Silveira Andrade-da et al. 2018)

Cashew nuts is one of the common nuts available in roasting market in Jordan, and is highly in demand by consumers due to its high energy and nutritional value as well as its unique flavors and taste, in addition to its health benefits. Due to its contents of monounsaturated fatty acids and polyunsaturated fatty acids, cashews consumption is related to reduce cardiovascular disease risk, especially in case of stroke, and decrease risk of metabolic syndrome, diabetes, mental health, weight gain and obesity (Sanhueza, Ryan et al. 2013, Mah, Schulz et al. 2017). It is also claimed that nuts are used to recover psychological problems (Carey, Poulose et al. , Herbison, Hickling et al. 2012), to improve mineral density in bones (Rivas, Romero et al. 2013) and to lower the rate of depression.

Lipid oxidation is one of the major causes of spoilage in high lipid food, especially high unsaturation lipid food such as cashew nuts. The rancid off flavor, toxic substance and loss of nutritional value due to degradation of polyunsaturated fatty acid (PUFA), make this product unacceptable for consumers (Maskan and Karataş 1999, Guillen and Goicoechea 2008, Ganiari, Choulitoudi et al. 2017).

Cashew nuts are main constituent in many processed foods including confectionery products, butters and bakery products. However, roasting of cashew alter its antioxidant activity by conversion of the phenolic acid composition such syringic, gallic, and p-coumaric acids. However, the addition of antioxidant and the use of edible film is one major efficient strategy applied to delay oxidation rancidity (Lopez-de-Dicastillo, Alonso et al. 2010). Synthetic antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and propyl gallate (PG), are used in many foods to prevent rancidity. However, their safety for human health is questionable (Pokorný 1991). Natural antioxidants like essential oils and tocopherols can act as natural antioxidant (Silva, Martinez et al. 2010, Quiroga, Riveros et al. 2011). The efficiency of these compounds is not enough in many cases (Bolumar, Andersen et al. 2011) and thus, edible coat with or without antioxidants could be an alternative method to preserve the product appearance, textural, nutritional and flavor properties during storage, and may elongate the shelf life of the product.

The objectives of this research are to study the effect of salting, roasting and Arabic gum coat on oxidative stability of roasted cashew nuts, without addition of any antioxidant, during storage for period of 10 months at room temperature. Furthermore, the cooperative effect of antioxidant (BHT and/or rosemary commercial extract) on the oxidative stability of cashew is also evaluated.

MATERIALS AND METHODS

Materials

Imported and vacuum packed raw and mature seeds of the cashew nuts (crop 2019) were purchased from BRAVO Company in Amman. Before processing, cashew nuts were inspected to remove damaged or bruised kernels, manually. Seven treated samples of cashew were prepared. The control samples were raw cashew nuts (C) and uncoated roasted cashew nuts (URC). Samples without antioxidants were roasted and coated cashew nuts with Arabic gum (RCC-G), salted, roasted and coated cashew with Arabic gum (RCC-G-S). Samples roasted and coated cashew nuts with Arabic gum were treated with 100 ppm BHT (RCC-G-BHT), 150 ppm rosemary commercial extract (RCC-G-Rose) and 100 ppm BHT together with 150 ppm rosemary commercial extract (RCC-G-BHT-Rose)

Arabic Gum Edible Coat Preparation

The Arabic gum powder (Hashab, Sudan origin) was purchased from a herbal shop (local market) and the solution was prepared by dissolving 500 g of gum powder with or without 100 mg BHT or 150 mg of rosemary extracts (dispersed separately in 20 ml ethanol) in 1 L solution. The solution was then allowed to equilibrate to room temperature.

Addition of Salt

After discharge of cashew in a special perforated tank, the cashew nuts was immersed for ten seconds in another tank containing 25% (w/v) NaCl solution in distilled water. Then, the salted cashews was sieved for 15 seconds to remove excess salt solution by lifting perforated tank up from salt solution tank. After that, roasting process was conducted with the same conditions on unsalted cashew. Filtered water was used to dissolve a powdered pure salt.

Cashews Roasting and Coating

Cashew was roasted using domestic rotating roaster at 140 °C, rotating at 28 rpm for 30 min, then roasted cashews will be spread on perforated stainless steel tray until reaches room temperature. Coating of roasted cashews was performed using centrifugal forces, through the rotating roaster by gradual pouring of Arabic gum coat suspension with and without BHT or rosemary extracts at BRAVO company (Alshaeb company) (Amman- Jordan).The drying off process after roasting and coating was performed so that the product has a moisture content between 1.2 and 2.0%. The coating percentage (CP %) was determined using the following formula:

$$\boldsymbol{CP}\% = \frac{\text{weight of coated cashew kernels} - \text{weight of original cashew kernels}}{\text{weight of original cashew kernels}} * \mathbf{100}\%$$

Storage Conditions and Samplings

After preparation, samples were placed in plastic containers under aseptic conditions. The samples were stored at 23°C ± 2°C(room temperature). Samples from each product were removed from storage to evaluate chemical indicators of lipid oxidation (Nepote, Olmedo et al. 2009). Samples were taken on monthly bases for ten months after storage. These storage times were chosen according to acceptable standard for the tests. Therefore, it is possible to draw conclusions about the effect of treatments on the shelf life and chemical properties of the product during this storage period.

Chemical Analysis

Cashew oil extraction: Oil was extracted from the roasted cashew nuts using a hydraulic cold pressing (Oilmaster, Dongguan Chuguan Electric Appliance Co., Ltd, Dongguan, China). The extracted cashew nut oil was used for the

chemical analysis such as peroxide value, free fatty acid (%) and Totox value.

Peroxide value (PV): PV was evaluated according to AOAC method (AOAC, 965.33, 2012), and was expressed as milliequivalents of active oxygen per kilogram of oil (meqO_2/kg).

Free Fatty acid: FFA % was evaluated according to AOAC method (AOAC, 940.28, 2012) (Chemists and Chemists 1995), and was expressed as oleic acid %.

p-Anisidine value (pAV): AV was evaluated following the IUPAC method (IUPAC, 1987) using UV-Visible spectrophotometer (Model UVD-2950, Labomed, Inc.) at 350 nm. The p-anisidine value was calculated using the formula:

$$pAV = 25\frac{1.25\ (\mathrm{As} - \mathrm{Ab})}{W}$$

Whereas, absorbance of the fat solution after reaction with the *p*-anisidine reagent, Ab is the absorbance of the fat solution and w is the mass of cashew nuts oil in grams.

Totox value (TV): Totox value was calculated using the PV and pAV results according to the formula:

$$Totox\ value = 2\ \mathrm{PV} + \mathrm{AV}$$

Statistical Analysis

Statistical calculations were performed using statistical analysis system, SAS program, 2000 (SAS Institute Inc., Cary, NC, USA). Data was analyzed using significant differences ofthe means of treatments using LSD test. Differences at P<0.05 was considered significant.

RESULTS AND DISCUSSIONS

Effect of Roasting, Coating, Salting, Storage and Antioxidant on FFA (%) of Cashew`s Oil

Table 1: Effect of Roasting, Coating, Salting and Storage on FFA (%) of Cashew`s Oil

	Storage time (month)									
FFA	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	0.34±.01^{a,A}	0.36±.00^{a,A}	0.36±.02^{a,C}	0.40±.01^{a,C}	0.61±.01^{b,B}	0.67±.00^{b,C}	0.96±.01^{c,D}	1.07±.05^{c,B}	1.40±.01^{d,F}	1.60±.07^{e,F}
URC	0.25±.01^{a,A}	0.24±.01^{a,A}	0.27±.02^{a,A}	0.31±.02^{a,A}	0.59±.08^{b,B}	0.68±.01^{bc,C}	0.78±.00^{c,C}	1.06±.12^{d,B}	1.30±.04^{e,E}	1.38±.03^{e,E}
RCC-G	0.32±.02^{a,A}	0.29±.07^{ab,A}	0.36±.01^{ab,C}	0.38±.01$^{ab,B C}$	0.41±.01^{b,A}	0.53±.01^{c,B}	0.55±.01^{c,B}	0.57±.03^{c,A}	0.63±.00^{c,B}	0.80±.03$^{d,C D}$
RCC-G+S	0.34±.00^{a,A}	0.33±.04^{a,A}	0.35±.01^{ab,C}	0.39±.01^{ab,C}	0.41±.01^{bc,A}	0.47±.02^{c,A}	0.56±.01^{d,B}	0.71±.01^{e,A}	0.82±.01^{f,D}	0.92±.01^{g,D}
RCC-G-BHT	0.33±.08^{a,A}	0.31±.02^{ab,A}	0.32±.01$^{ab,AB C}$	0.33±.01^{ab,A}	0.38±.01^{abc,A}	0.43±.01^{bcd,A}	0.47±.02^{cde,A}	0.51±.02^{de,A}	0.54±.01^{e,A}	0.56±.02^{e,A}
RCC-G-Rose	0.29±.01^{a,A}	0.32±.03^{ab,A}	0.35±.01^{ab,BC}	0.34±.01$^{b,A B}$	0.41±.02^{c,A}	0.54±.02^{d,B}	0.56±.01^{d,B}	0.58±.00^{d,A}	0.60±.00$^{de,A B}$	0.64±.01$^{e,A B}$
RCC-G-BHT-Rose	0.34±.00^{a,A}	0.30±.02^{a,A}	0.29±.01^{ab,AB}	0.39±.01^{bc,C}	0.42±.03^{c,A}	0.55±.01^{d,B}	0.60±.01^{de,B}	0.66±.01^{e,A}	0.71±.00^{f,C}	0.77±.01$^{g,B C}$

Each value represents the mean of duplicate ± SD, Different superscript (a,b,c,d,e,f,g and h) within the same row is significantly different (P≤0.05). Different superscript with Latin number (A, B,C,D,E and F) within the same column is significantly different (P≤0.05).

Analysis of variance (ANOVA) was conducted to point out the significant ($P<0.05$) in the variation of the mean values of FFA (%) throughout storage for raw and treatments of cashews sample. Table (1) shows comparisons between treated samples through ten months of storage time. In term of storage time, the FFA% value increased significantly ($p < 0.05$) in all samples after the fourth month, compared with nearly stable values in the first four months. All roasted samples had significant low FFA % after four months of storage due to reduction of water contents of all cashew as a result of exposing all the samples to the same moisture environment, which plays major role in hydrolytic rancidity. However, the increase in FFA% of raw cashew (C) was higher than the roasted uncoated cashew (URC) and both have higher values than other samples. This indicates the positive effect of roasting and coating in diminishing hydrolytic rancidity. In spite the relatively high value of FFA% of raw cashew (C), this value is considered to be lower than accepted value, which may be due to low lipase content of cashews. Samanta and Rege (Samant and Rege 1990) showed that the lipase enzyme and lipoxygenase, amylase- and trypsin inhibitor content of cashew is low. This low content of lipase may be responsible for the higher FFA% value (1.6%) of raw cashew compared with all roasted cashew after ten months of storage. Thus, the heat of roasting has a destructive effect on enzymes of cashews. This low lipase content directly affects the lipolysis and mitigates the autoxidation of fatty acids from extracted oils.

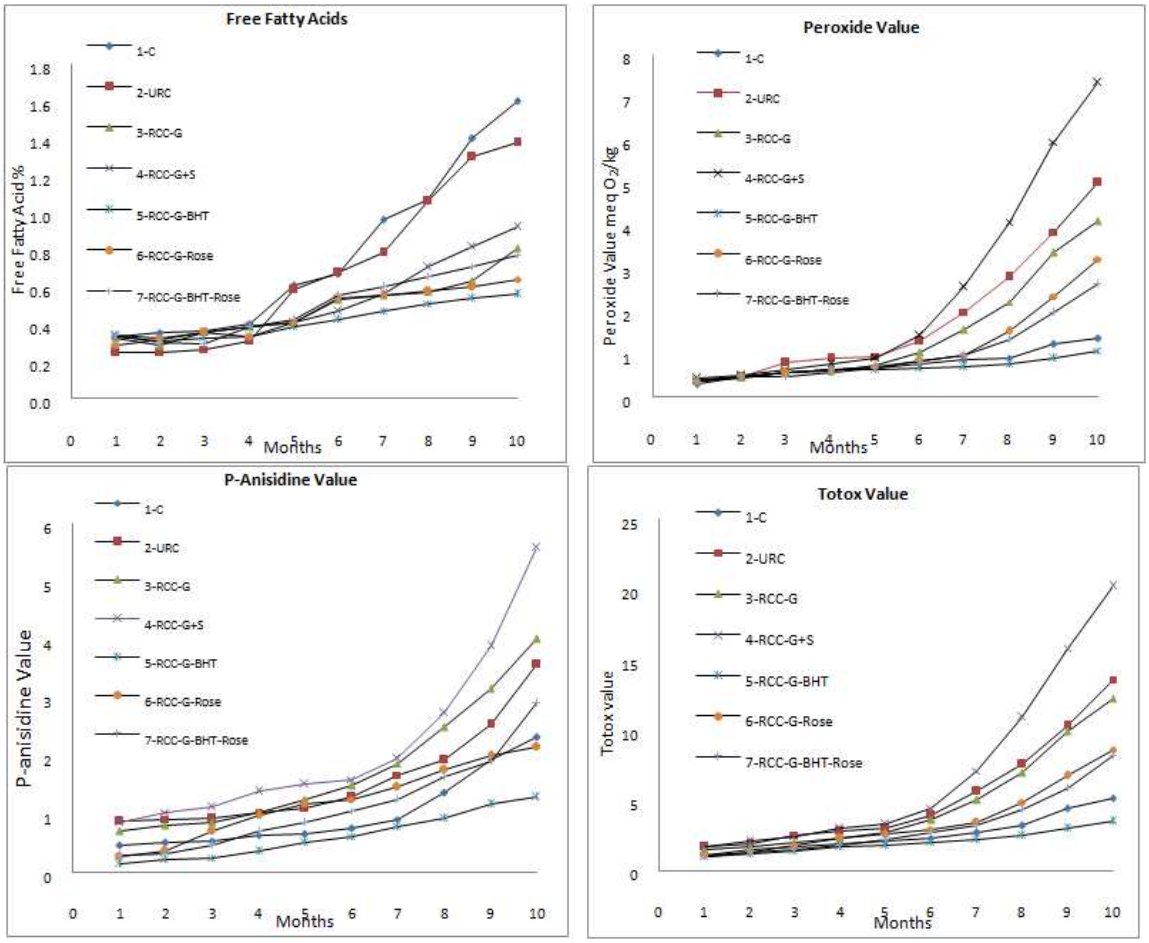

Figure 1: Chemical Analysis Results: A) Free Fatty Acid (FFA). B) Peroxide value (PV) and C) p-Anisidine Value (pAV). D) Totox Value of Raw Cashew Nuts (C), Uncoated Roasted Cashew (URC) as Control Sample, Roasted and Coated Cashew with Arabic gum (RCC-G), Salted, Roasted and Coated Cashew with Arabic gum (RCC-G-S) Roasted and Coated Cashew with Arabic gum and 100 ppm BHT (RCC-G-BHT), Roasted and Coated Cashew Nuts with Arabic gum and 150 ppm Rosemary Commercial Extract (RCC-G-Rose) and Roasted and Coated Cashew Nuts with Arabic gum and 100 ppm BHT and 150 ppm Rosemary Commercial Extract (RCC-G-BHT-Rose) during Storage

Fatty acid composition of cashew is susceptible to rancidity development and subsequence off-flavors through lipid oxidation (Frankel 2014). Fatty acid profile of cashew shows that cashew have trace amount of short chain FA and the majority (about 80 %) is unsaturated long chain fatty acid (Aremu, Ogunlade et al. 2007). Consequently, the off-flavor of cashew during storage may indicate autoxidation of lipid rather than fat deterioration resulted from hydrolysis of triglycerides to FFA (Gardner 1975).Nepote et al reported the PV, p-Anisidine value, conjugated dienes and trienes tests of roasted peanuts with a high and regular -oleic cultivar, and found that high oleic cultivar peanuts had shelf lives of 25 (at 23 °C) and 10 (at 40 °C) times longer than regular oleic cultivar samples (Nepote, Mestrallet et al. 2006).

As shown in Figure (1), the cashew FFA (%) remains below 2 % even after ten months of storage, which is the quality standard of codex for virgin oils (Alimentarius 1999).

The FFA% of salted coated and roasted (RCC-G-S) cashews (0.92 %) was found to be significantly higher than coated cashew with BHT and rosemary (RCC-G-BHT, RCC-G-Rose and RCC-G-BHT-Rose). This result leads to a conclusion that addition of salts enhances hydrolytic rancidity and increase FFA%. This conclusion is consistent with the results about the effect of addition of NaCl to a Chinese fermented soybean food which was reported to increase FFA level (Han, Wang et al. 2003). As shown in Table (1), the addition of BHT and rosemary significantly reduce FFA % due to reduction enzymatic hydrolysis of ester bond of triglycerides (TG) to produce FFAcompared with raw, roasted and coated samples. Furthermore, BHT coated cashew (RCC-G-BHT) has the lowest FFA% (0.56%) and had significant difference compared with samples containing rosemary extract coat (RCC-G-Rose and RCC-G-BHT-Rose).

3.2 Effect of Roasting, Coating, Salting, Storage and Antioxidant on Peroxide Value of Cashew`s Oil

Table (2) represents the peroxide value (PV) in mill equivalents of active oxygen per kilogram of oil for all seven cashew samples. A slight increase in PV was noticed throughout the first five months of storage then significant increase continued 10th month. The results showed that samples contained BHT and rosemary extract had the lowest peroxide value after the 5th month five month of storage until the end of storage time. RCC-G-BHT sample had a PV of 1.09 (meqO2/kg) which is significantly lower than 3.23 and 2.64 (meqO2/kg) for RCC-G-Rose and RCC-G-BHT-Rose, respectively. This indicates that addition of BHT to Arabic gum coat is more effective antioxidant than rosemary and rosemary mixed with BHT with Arabic gum coat. However, rosemary extract coat (RCC-G-Rose) is also effective as antioxidant, since it had 3.23(meqO2/kg) peroxide value which is significantly lower than control sample (RCC-G) with 4.1(meqO2/kg). This finding is consistent with the study of Mestrallet et al on whey protein coating of peanuts which indicated that incorporation of whey protein layer with antioxidant gives better antioxidant efficacy (Riveros, Mestrallet et al. 2013). Furthermore, roasted sample without Arabic gum coat (URC) had a peroxide value of 5.01, which is significantly higher than uncoated control sample (RCC-G). Riveros et al reported PV and p-anisidine values of peanut coated with different edible coatings: carboxymethyl cellulose, methyl cellulose or whey protein during storage at 40 °. They found that PV value of roasted peanut (RP) is significantly higher than coated roasted peanuts samples. (Riveros, Mestrallet et al. 2013). In another study of the effect of pure (gelatin, chitosan, sodium casein ate) or blended (gelatin: chitosan, gelatin: sodiumcaseinate) coating solutions on cashews and Brazil, the results showed that coating protect those nuts from oxidation during 120 day of storage (Bonilla, Poloni et al. 2018). These studies support that the mixing and coating of materials with artificial and natural antioxidant can enhance antioxidant ability of nuts.

Table 2: Effect of Roasting, Coating, Salting and Storage on Peroxide Value (%) of Cashew`s Oil

	Storage time (month)									
Peroxide	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	0.30±.02 a,A	0.49±.01 ab,A	0.58±.01 bc,B	0.63±.01 bcd,A	0.69±.01 cde,A	0.78±.02 def,A	0.87±.01 ef,A	0.93±.01 f,A	1.23±.12 g,A	1.39±.10 g,A
URC	0.39±.08 a,A	0.47±.01 ab,A	0.81±.02 bc,D	0.89±.01 c,D	0.96±.02 cd,B	1.30±.02 d,C	1.99±.16 e,C	2.81±.13 f,D	3.86±.16 g,C	5.01±.03 h,E
RCC-G	0.38±.03 a,A	0.46±.00 ab,A	0.56±.01 ab,B	0.61±.01 ab,A B	0.73±.03 bc,A	1.05±.08 c,B	1.56±.06 d,B	2.22±.12 e,C	3.37±.18 f,C	4.10±.1 g,D
RCC-G+S	0.43±.02 a,A	0.50±.01 ab,B	0.65±.02 abc,C	0.79±.01 bc,C	0.90±.03 c,B	1.43±.1 d,C	2.57±.1 e,D	4.09±.12 f,E	5.96±.11 g,D	7.34±.12 h,F
RCC-G-BHT	0.42±.01 a,A	0.47±.01 a,A B	0.58±.01 b,B	0.64±.03 bc,B	0.65±.01 bc,A	0.68±.00 c,A	0.71±.02 cd,A	0.77±.03 d,A	0.91±.02 e,A	1.09±.02 f,A
RCC-G-Rose	0.39±.02 a,A	0.48±.01 ab,A B	0.56±.02 ab,B	0.66±.01 abc,B	0.72±.01 bcd,A	0.84±.01 cd,A	0.99±.06 d,A	1.55±.10 e,B	2.36±.18 f,B	3.23±.06 g,C
RCC-G-BHT-Rose	0.37±.02 a,A	0.46±.00 ab,A B	0.49±.01 ab,A	0.57±.01 ab,A	0.66±.03 bc,A	0.83±.03 cd,A	0.97±.06 d,A	1.34±.02 e,B	1.96±.12 f,B	2.64±.09 g,B

Each value represents the mean of duplicate ± SD, Different superscript (a,b,c,d,e,f,g,h and i) within the same row is significantly different (P≤0.05). Different superscript with Latin number (A,B,C,D,E,F and G) within the same column is significantly different (P≤0.05)

Table (2) indicates that the first three months of storage time at room temperature had no considerable influence on samples, and this led to a conclusion that BHT and rosemary extract start their antioxidant effect after three months of storage time. However, the sharp increase in peroxide value start after the 7th month of storage.The PV of samples at the 10th months were below 7.5 meq O2/kg, which is much less than the acceptable PV for other nuts that should be less than 20 meq O2/kg (Mehyar, Al-Ismail et al. 2012). Another study investigated oxidative stability of roasted peanuts coated with prickly pear and algarrobo pod syrups when stored at 23C for 112 days. They concluded that PV reached 10 meqO2/kg after 8.5 days in roasted peanuts, 20.7 days in roasted peanuts coated with prickly pear syrup and 29.5 days in roasted peanuts coated with algarrobo pod syrup at 23C (Mestrallet, Nepote et al. 2009). This difference in peroxide value between cashews and other nuts may relate to the effective antioxidant that present naturally. This makes cashew as one of the most stable nuts, and have longer shelf life compared with other nuts (such as peanuts).

The results in Table (2) showed that the PV of RCC-G+S (7.34meqO2/kg) was significantly higher than the unsalted sample control (RCC-G) and samples containing BHT (RCC-G-BHT) and rosemary (RCC-G-Rose).

3.3 Effect of Roasting, Coating, Salting and Storage on p-Anisidine Value (%) of Cashew's Oil

p-Anisidine value (pAV)measures the secondary products of oxidation resulted from peroxide radical degradation, which give volatile compounds like aldehydes primarily 2-alkenals and 2,4-alkadienals generated due to hydro peroxide decomposition, and it is more sensitive to unsaturated aldehydes in oil and fat(Gordon 2001).

Table 3: Effect of Roasting, Coating, Salting and Storage on p-Anisidine Value (%) of Cashew`s Oil

	Storage time (month)									
Anisidine	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	0.47±.01 a,C	0.51±.00 ab,C	0.54±.01 abc,C	0.62±.01 bc,B	0.66±.01 cd,B	0.75±.02 d,A	0.91±.02 e,A	1.37±.07 f,B	1.94±.06 g,B	2.31±.01 h,B
URC	0.87±.02 a,E	0.91±.01 ab,D	0.92±.02 ab,F	1.04±.02 ab,C	1.09±.02 bc,D	1.30±.08 c,B C	1.67±.09 d,D	1.93±.07 e,D	2.55±.01 f,C	3.58±.09 g,D

Table 3: Contd.,

RCC-G	0.70±.02 a, D	0.81±.01 a,D	0.84±.00 a,E	1.03±.07 b,C	1.23±.01 c,E	1.49±.04 d,C D	1.87±.03 e, E	2.50±.05 f,E	3.17±.07g , D	4.02±.04 h, E
RCC-G+S	0.84±.01 a, E	1.03±.07 ab, E	1.12±.02 b,G	1.39±.02 c,D	1.51±.02 c,F	1.60±.02 c,D	1.95±.02 d, E	2.73±.11 e,E	3.90±.12 f, E	5.58±.06 g, F
RCC-G-BHT	0.15±.01 a, A	0.21±.01 a,A	0.25±.00 ab,A	0.37±.01 b,A	0.50±.02 c,A	0.62±.01 c,A	0.78±.02 d, A	0.92±.03 e,A	1.16±.07 f, A	1.29±.05 g, A
RCC-G-Rose	0.26±.00 a, B	0.36±.01 a,B	0.70±.00 b,D	0.98±.01 c,C	1.18±.03 d,E	1.25±.02 d,B C	1.45±.04 e, C	1.75±.04 f,C D	2.01±.04 g, B	2.16±.07 h, B
RCC-G-BHT-Rose	0.28±.01 a, B	0.32±.01 a,A B	0.46±.00 a,B	0.70±.01 b,B	0.84±.01 b,C	1.06±.13 c,B	1.25±.00 c, B	1.63±.02d C	1.91±.05e , B	2.90±.08 f, C

Each value represents the mean of duplicate ± SD, Different superscript (a,b,c,d,e,f,g,h and i) within the same row is significantly different (P≤0.05). Different superscript with Latin number (A,B,C,D,E,F and G) within the same column is significantly different (P≤0.05).

Table (3) presents the changes of p-Anisidine value (pAV) of cashew oil extract as a function of storage time. In general, thepAV of the seven cashew samples increase slightly during the first six months of storage.Then they considerably increased until the end of storage time in the 10th months. Riveroset al (2012) found that pAVof peanut coated with different edible coatings (carboxymethyl cellulose, methyl cellulose or whey protein) during storage at 40 °C (Riveros, Mestrallet et al. 2013).The results also shows that cashew coated with Arabic gum mixed with BHT or rosemary or both (RCC-G-BHT, RCC-G-Rose and RCC-G-BHT-Rose) significantly had a higher pAV compared with Arabic gum coated cashew oil extract alone (Table (3)). At the end of ten month of storage, BHT-Arabic gum cashew coat had the lowest pAV of 1.29 followed by cashew containing mixture of BHT and rosemary (2.16) then the one containing only rosemary (2.9). Although BHT had higher antioxidant efficacy than all other samples, rosemary coating had also considerable antioxidant efficacy when compared with control sample (RCC-G). As in the case of PV, samples containing salt had significantly higher pAV at 9th and 10th months of storage (3.9 and 5.58, respectively) than all other samples. Furthermore, raw cashews (C) had significantly lower pAV of 2.31 than uncoated roasted cashews (URC) of3.58 which may indicate that roasting may increase pAV. Thus, roasting had negative effect on oxidative stability of cashew, which agreed withShafiei et alstudy on estimating the stability of hazelnuts using accelerated shelf-life testing. Roasting without coating of hazelnuts increases the pAV and PV levels. (Shafiei, Ghorbani et al. 2020).

The highest pAV value in Table (3)is less than 5.6 that is much lower than the acceptable quality standard of pAV, which should be less than 10 (Talbot 2016).This means that all prepared sample were stable when stored at room temperature and under the condition of storage.

3.4. Effect of Roasting, Coating, Salting and Storage on Totox Value (%) of Cashew's Oil

Totox value measured both primary and secondary products (PV and pAV) of oil and fat oxidation. After formation of primary products, some of these products are oxidized further and split to give secondary products like aldehydes or ketons. Table (4) presents the changes in totox value of the 7 cashew samples during 10 month of storage. During the first five months of storage, the totoxvalue of all samples increased slightly then the difference between samples starts to increase until the end of storage time.

Table 4: Effect of Roasting, Coating, Salting and Storage on Totox Value (%) of Cashew`s Oil

	Storage time (month)									
Totox	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	1.06±.03^{a,A}	1.49±.02^{ab,C}	1.71±.02^{bc,B}	1.88±.02^{bcd,B}	2.04±.00^{cd,B}	2.32±.06^{de,B}	2.66±.04^{e,B}	3.22±.09^{f,B}	4.40±.29^{g,B}	5.09±.2^{2h,B}
URC	1.66±.19^{a,B}	1.85±.01^{ab,D}	2.53±.03^{bc,E}	2.82±.05^{c,D}	3.00±.07^{c,D}	3.89±.012^{d,D}	5.66±.42^{e,C}	7.54±.20^{f,F}	10.27±.31^{g,D}	13.59±.16^{h,E}
RCC-G	1.45±.05^{a,B}	1.72±.00^{ab,D}	1.97±.03^{ab,D}	2.26±.10^{bc,C}	2.70±.07^{c,C}	3.59±.20^{d,D}	4.99±.16^{e,C}	6.94±.18^{f,E}	9.91±.44^{g,D}	12.22±.15^{h,D}
RCC-G+S	1.71±.03a^{,B}	2.04±.08^{ab,C}	2.42±.01^{bc,E}	2.96±.04^{cd,D}	3.30±.04^{d,E}	4.46±.18^{e,E}	7.09±.22^{f,E}	10.92±.12^{g,G}	15.82±.34^{h,E}	20.26±.30^{i,F}
RCC-G-BHT	0.99±.02^{a,A}	1.15±.03^{a,A}	1.42±.04^{b,A}	1.64±.05^{c,A}	1.80±.03^{cd,A}	1.97±.01^{d,A}	2.20±.05^{e,A}	2.46±.03^{f,A}	2.99±.02^{g,A}	3.46±.1^{h,A}
RCC-G-Rose	1.05±.05^{a,A}	1.31±.01^{a,B}	1.82±.04^{b,C}	2.30±.02^{bc,C}	2.62±.05^{cd,C}	2.94±.05^{de,C}	3.43±.16^{e,B}	4.86±.16^{f,D}	6.73±.31^{g,C}	8.61±.05^{h,C}
RCC-G-BHT-Rose	1.01±.02^{a,A}	1.24±.00^{ab,A}	1.44±.01^{bc,A}	1.83±.02^{cd,B}	2.17±.08^{d,B}	2.72±.18^{e,BC}	3.20±.13^{f,B}	4.31±.01^{g,C}	5.84±.19^{h,C}	8.18±.10^{i,C}

Each value represents the mean of duplicate ± SD, Different superscript (a,b,c,d,e,f,g,h and i) within the same row is significantly different (P≤0.05). Different superscript with Latin number (A,B,C,D, E,F and G) within the same column is significantly different (P≤0.05)

Table (4) shows that BHT coated sample (RCC-G-BHT) had totox values of 2.46, 2.99 and 3.46 in the 8th, 9th, 10th months, respectively which were significantly lower than all other samples. Since raw cashew (C) was not exposed to heat treatment, it had a totox value lower than other treated samples, except BHT containing sample (RCC-G-BHT). In the last two months, RCC-G-Rose and RCC-G-BHT-Rose had a totox value (6.73 and 8.61for RCC-G-Rose and 5.85 and 8.18 for RCC-G-BHT-Rose respectively) significantly lower than control sample (RCC-G) of 12.22.

Roasted uncoated sample (URC) had a totox value significantly greater than raw sample (C) during all ten storage months, which lead to a conclusion that heat of roasting lead to increase in the primary and secondary oxidation products. For salt containing coat of cashew (RCC-G+S), totox value was significantly greater than all other samples from the 5thto the 10th month. The comparison between roasted uncoated and Arabic gum coating cashew shows that Arabic gum coating sample was significantly lower than roasted uncoated sample with 13.59 at the end of storage time which indicate that hydrocolloid like Arabic gumis effective in preventing oxidation. This result agreed with work of Wambura et al. that samples containing carboxymethyl cellulose had higher oxidative stability index (OSI) compared with control, whey and ziencorn protein (Wambura, Yang et al. 2008). Also, Lee and Krochta (2002) studied whey protein coatedpeanuts using head space gas chromatography at 40,50 and 60 °C storage temperature for 31 weeks, and found that whey protein coated samples were significantly oxidized slower than uncoated roasted ones (Lee and Krochta 2002).In another study,Han et al. also studied roasted and whey protein coated peanut with addition of tocopherols and ascorbic palmitate as antioxidants during 16 weeks at 25 °C by measuring hexanal and other volatiles using GC-MS as lipid oxidation indicator, and they observe that the formation of hexanal from the oxidation of peanut lipids was reduced by whey protein coatings (Han, Hwang et al. 2008). Wambura et al showed that peanuts coated with carboxymethylcellulose and natural antioxidant from pomegranate improved the oxidative stability of roasted peanuts during storage (Wambura, Yang et al. 2010).

The results in Table 1- 4 indicated that cashew had long storage time with low oxidation indices such as FFA%, PV, pVA and totox. This long stable storage time could be related to the abundance of tocopherol, gallic acid, alkyl phenols (anacardic acids), hydroxy alkyl phenols and another natural antioxidant in raw and roasted cashew (Gómez-

Caravaca, Verardo et al. 2010, Vinson and Cai 2012). Vinson and Cai reported that roasted cashew had the highest antioxidant efficacy among nuts, which was proved by measuring the IC50 (The concentration to inhibit the oxidation by 50%) that decrease in the following order: almond = Macadamia = pecan = peanut butter crunchy > peanut butter creamy > peanut > pistachio > hazelnut = walnut > Brazil > cashew. Roasting of cashew was found to increase the efficacy while roasting of the other nuts caused significant decline in their efficacy. Chandrasekara and Shahidifound that high temperature/short time roasting enhance antioxidant efficacy of cashew nuts because of the effect of high temperature of roasting (130 °C for 33 min) on oxidation activity such as the 1,1-diphenyl-2-picrylhydrazyl (DPPH), radical scavenging capacity, oxygen radical absorbance capacity, hydroxyl radical scavenging capacity, trolox equivalent antioxidant activity, and reducing power (Chandrasekara and Shahidi 2011).

Gómez-Caravaca used chromatographic techniques for determination antioxidant compound in raw and roasted cashew oil obtained by cold pressed extraction and found that anacardic acids were the major alkyl phenols contained in both oils followed by cardol, cardanol and 2-methylcardol compounds. Raw and roasted oils did not show different compositions except for cardanols. The oil produced from roasted cashew nut was found to contain higher concentration of cardanols than raw oil. Furthermore, raw cashew was found to contain 171.48 mg/100g tocopherol compared with 29.56 mg/100g in roasted cashew due to reduction in β-tocopherol. Also, minor polar compounds in cashew oil decreased as a result of roasting from 346.52 to 262.83 mg/kg (Gómez-Caravaca, Verardo et al. 2010). Another study reported that cashew contains alkyl phenols as the principal antioxidant such as 8.68 mg/100g Proanthocyanidins and 1.98 mg/100g flavonoids as well as phytochemicals such as 22 µg/100g carotenoids, 0.9mg/100g α-tocopherol, 0.03 mg/100g β-tocopherol and 5.31 mg/100g γ-tocopherol(López-Uriarte, Bulló et al. 2009). All these antioxidant compounds work in synergy with other components of cashew nuts to enhance antioxidant activities, which lead to prolong storage time of cashews.

CONCLUSIONS

Generally, cashew nuts reveal high oxidation stability that may prolong for more than ten months, because of its content of natural antioxidant in addition tobioactive constituents. FFA% of raw cashew has the highest level compared with roasted, coated and salted cashew nuts when stored at room temperature. Salting of cashew nuts has destructive effect on cashew as reflected by peroxide value, p-anisidine value and totox value, which give indicated enhancement of autoxidation process and decrease oxidative stability and shelf life of cashew. Roasting of cashew reduce hydrolytic rancidity and oxidative stability of cashew nuts as reflected by FFA%, peroxide, p-anisidine and totox values. Arabic gum coated cashew immersed with 100 ppm BHT has the efficient antioxidant effect, but its use is questionable. In spite of effectiveness of addition of rosemary extract (150ppm) as natural antioxidant and extending the shelf life of cashew, the antagonistic effect between rosemary and BHT increase peroxide, p-anisidine and totox levels.

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Table 5

Abbreviation	Abbreviation Caption
Ab	Absorbance of the fat solution
As	Absorbance of the fat solution after reaction with the *p*-anisidine reagent
ANOVA	Analysis of variance
AG	Arabic gum
AOAC	Association of official analytical chemists
BHA	Butylated hydroxyanisole
BHT	Butylated hydroxytoluene
CMC	Carboxymethyl cellulose
C	Raw cashew
°C	Degree Celsius
CP	Coating percentage
DPPH	1,1-diphenyl-2-picrylhydrazyl
FA	Fatty acids
FFA	Free fatty acids
g	Gram
IUPAC	International union of pure and applied chemistry
Kg	Kilo gram
kj	Kilo joul
LDL	Low density lipoproteins

Table 5: Contd.,

LSD	Least significant difference
MC	Methyl cellulose
meqO_2/kg	Milliequivalents of active oxygen per kilogram of oil
min	Minute
mg/kg	Milligram per kilogram
NaCl	Sodium cloride
NFE	Nitrogen-free extract
ORAC	Oxygen radical absorbance capacity
pAV	Para- Anisidine value
PG	Propyl gallate
PV	Peroxide value
PUFA	polyunsaturated fatty acid
RCC-G	coated cashew with Arabic gum
RCC-G-BHT	roasted and coated cashew with Arabic gum and 150 ppm BHT
RCC-G-BHT-Rose	roasted and coated cashew nuts with Arabic gum and 150 ppm BHT and 150 ppm rosemary commercial extract
RCC-G-Rose	roasted and coated cashew nuts with Arabic gum and 150 ppm rosemary commercial extract
RP	Roasted peanut
rpm	Round per minutes
RT	Room temperature
SAS	Statistical analysis software
SD	Standard deviation
TEAC	Trolox equivalent antioxidant activity
TG	Triglycerides
TV	Totox value(2PV + pAV)
URC	uncoated roasted cashew
USFA	Unsaturated fatty acids
VLDL	Very low-density lipoprotein
W	Mass of cashew nuts oil in grams
WPI	Whey protein isolate
w/v	Weight per Volume
%	Percent