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Studies on storage stability of hot extracted (HEVCO) and cold extracted virgin coconut oil (CEVCO) in different flexible and rigid packaging system

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Abstract

The storage stability of virgin coconut oil was found to be one year in different flexible [linear low density polyethylene (LLDPE), low density polyethylene (LDPE), Metallised polyester (MET)] and rigid packaging material [polyethylene tetra phthalate (PET) bottle, high density polyethylene (HDPE) and amber high density polyethylene (AHDPE)] at room temperature (15-35˚C) and 37°C. Peroxide value (PV), free fatty acid (FFA), thiobarbituric acid (TBA), total carbonyl (TC) and anisidine value (AV) was increased during storage period. There was no significant ($p \leq 0.05$) increase in refractive index (RI) and moisture content observed in VCO samples at both types of packaging system. The study concluded that packaging system, storage time and temperature all have significant effect on the stability of hot and cold extracted virgin coconut oil.

Introduction

The major function of packaging system is to minimize reactions that affect the stability of the contained products (Karel and Heidelburgh, 1975). The quality and shelf life of the packaged food are mainly determined by the barrier properties of the package against moisture, oxygen and interaction of food constituents with the packaging material (Sharma *et al.*, 1996). Earlier, storage stability of sunflower oil in glass and polyethylene tetra phthalate (PET) (Kucuk and Caner, 2005), olive oil, sunflower oil and palm oils in plastic films (like polyethyleneterephthalate, polyvinylchloride, polypropylene and polystyrene) (Tawfik and Huyghebaert, 1999) already studied. Sharma *et al.* (1990) studied the effect of plastic film contact, including polyethylne, polypropylene and Butylated hydroxyl anisole and butylated hydroxyl toluene incorporated in polyethylene, on the storage stability of refined sunflower oil and groundnut oil at 37°C. Nkpa *et al*. (1990, 1992) have shown that crude palm oil, packaged in clear plastic bottles, sealed polyethylene film and clear glass bottles, recorded higher total oxidation values than oils packed in either lacquered metal or amber, green glass bottle. Mathews *et al.* (1998) had worked out the storage quality of groundnut oil packed in tin-free steel and tin plate containers. Suitability of different packaging materials for packaging of refined groundnut oil has been studied by Srinivasa Gopal *et al.* (1977). Groundnut oil packed in fresh containers was found acceptable for about 8 months, while the oil packed in once used containers was not acceptable after 4-5 months (Grover *et al*., 1982). The shelf life of refined groundnut oil packed in flexible packaging material was hardly 20 days at 40°C, 90% RH in polyolefin film pouches and 60-80 days in laminated pouches (Baldev Raj *et al.*, 1985). Ana *et al.* (2007) had analyzed four commercial samples of extra-virgin olive oil in clear PET bottle, PET bottle (covered with Al foil), glass bottle, tin and tetra brik. Padmashree *et al.* (2009) had reported packaging system for refined vegetable oils for Indian army to overcome transit damage and consequent loss through leakage of contents. Anwar *et al*. (2007) had carried out study in order to probe the extent of oxidative alterations in soyabean oil, subjected to ambient and sunlight storage, over a period of 180 days. During storage of virgin grape seed oil, the pleasant sensory attributes changes and more degradation products like ethyl acetate, acetic acid or ethanol are detectable (Bertrand, 2008). Azeredo *et al.* (2003) maximized the sensory stability of soybean oil packaged in pet bottles. Nobile *et al.* (2003) reported that it is possible to obtain quality decay kinetic slower than that obtained for olive oil bottled in glass containers by either using an oxygen scavenger or reducing the concentration of oxygen dissolved in the oil prior to bottling

Now-a-days, a large number of processed products like minimally processed tender nut, coconut chips and coconut beverage prepared from coconut are available in market and are receiving encouraging response from the consumers. Coconut oil is made from copra which is dried kernel or meat of coconut.

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On the other Virgin Coconut Oil (VCO) is extracted from fresh, mature kernel of the coconut by natural means with or without application of heat. It has more nutritionally beneficial effect than copra oil because it retains most of its functional components (Marina *et al*., 2009). Some Virgin Coconut Oil may have a smoky flavor and slight yellowish color. To protect the oil's essential properties, the production of virgin coconut oil does not undergo chemical refining, bleaching, or deodorizing. It is fit for consumption without any further processing. VCO is an emerging product of importance from coconut, both in the local and foreign market (Corpuz, 2004). Virgin coconut oil is rich in medium-chain fatty acids (MCFA) such as C:8, C:10 and C:12 having numerous health benefits: Virgin coconut oil contains lauric acid, which is considered to be very helpful in preventing infections caused by virus, protozoa and bacteria. VCO has capability to increase antioxidant enzymes and reduce lipid peroxidation (Nevin and Rajamohan, 2004). It has more antithrombotic effect over copra oil (Nevin and Rajamohan, 2006). Lauric acid and its derivative monolaurin are both reckoned to be effective in destroying viruses such as HIV, herpes, influenza and cytomegalovirus. Virgin coconut oil stimulates metabolism and provides an immediate source of energy. Nevin and Rajamohan (2004) reported that Virgin coconut oil lowered total cholesterol, triglycerides, phospholipids, low density lipoprotein, very low density lipoprotein cholesterol and increased the high desity lipoprotein cholesterol in serum and tissues compared to copra oil.

The current study was undertaken to evaluate the effect of different factors including time, temperature, packaging material type on the storage stability of VCO. In the present investigation, the oxidation was determined by following changes in peroxide value and the carbonyls, the final products of oxidation.

Materials and Methods

Raw materials

Virgin coconut oil obtained from Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala, India. The packaging materials LDPE (75µ), LLDPE (75µ), Metallised polyester (75µ), PET (500µ), HDPE (500µ), Amber HDPE (500µ) bottle were procure from Darshan Flexibles Pvt. Ltd., Ansar traders, Matha Packaging Mysore.

Extraction of VCO

VCO was extracted by the method prescribed by Villarino *et al.* (2007) with some modifications. Major steps involved were production of coconut milk and extraction of oil. Extraction of oil was done by two ways viz. cold and hot extraction process.

Preparation of coconut milk

The production of coconut milk involves selection of nut, dehusking, deshelling, testa removal, washing, grating and milk extraction. Fully matured 10-11 months old coconut nuts were selected for VCO production. As an indicator of maturity of the nut, the husk was yellowish to brown in colour and made a sloshing sound when shaken. By a special type of tool the husk and shell was removed without breaking the coconut kernel. After breaking the coconut in two halves, kernel was scooped out by knife. The testa of coconut kernel was removed by testa remover machine. The coconut kernel free from testa was washed and fed to the mechanical grating machine (contain rotating blades). Coconut milk was extracted from the grated coconut meat manually using manually operated hydraulic coconut milk press. The coconut milk obtained from the first extraction was collected separately and residue was utilized for second and third extraction. Pool the first, second and third milk extracts by stirring vigorously for few min.

Preparation of cold extracted virgin coconut oil (CEVCO)

In cold extraction method, coconut milk was allowed to stand for 20-24 hrs. Under favorable conditions (35-40˚C, 75% Relative Humidity), the oil gets separated from the water and the protein. The air borne lactic acid bacteria, which has the capability to break the protein bonds, act on the coconut milk mixture causing the VCO separation. The fermenting container should be made up of food grade, transparent plastic. It should be wide mouthed for easy removal of curd. The extraction container can also be a food grade stainless steel cylindrical tank with a conical bottom with outlet tap specified and a sight glass to see the different layers as the oil separates. Oil can be withdrawn from the outlet tap based on the levels shown in the sight glass. Proper operating conditions and sanitary precautions were strictly followed. Four distinct layers could be visible in the container after settling for 20-24 hrs. The bottom layer was made up of gummy sediment. The next layer was the watery, skim milk that is no longer fit for human consumption. The next layer was the separated oil for recovery as VCO. The top layer was floating curd. The curd also contained a considerable amount of trapped oil. By carefully separating the distinct layers, the oil can be separated. The separated oil contained some adhering particles of curd and it need filtration. Oil was filtered

through sterilized filter paper placed in big funnel.

Preparation of hot extracted virgin coconut oil (HEVCO)

Coconut milk is an emulsion of oil and water that is stabilized by protein. To recover the oil from coconut milk, the protein bond had to be broken by heat in double walled boiler known as VCO cooker under slow heating to coagulate the protein and release the oil. Separate the class A oil from the protenacious residue (kalkam) by straining the mixture through a muslin cloth.

Protocol for storage stability of hot and cold process VCO

Hot and cold VCO were obtained from CPCRI and stored in 500 ml of different packaging material such as linear low density polyethylene (LLDPE), low density polyethylene (LDPE), metallised polyester (MET) and polyethylene tetra phthalate (PET) bottle, high density polyethylene (HDPE) and amber high density polyethylene (AHDPE) stored at room (15-35˚C) and 37˚C temperature. Headspace oxygen was negligible and the same since the containers were filled just below the seal line and under anaerobic conditions. Initially and after each month, stored samples were analysed for peroxide value (PV), thiobarbituric acid value (TBA), refractive index (RI), free fatty acid (FFA) by AOCS (1990), anisidine value (AV) by List *et al.* (1974), colour value by Henick *et al.* (1954). The sensory acceptance tests of stored VCO sample was done by 25 semi-trained panelists on the basis of aroma, taste and overall acceptability on 9 point hedonic scale having 9 for excellent in all respects and 1 for complete unacceptability after frying the soaked bengal gram dhal on the other hand oil samples as such were also served to panel members for detection of any stored odor (Larmond, 1997). The experiments were run in duplicate and analyses were done in triplicate.

Estimation of free fatty acid (FFA) content, peroxide value (PV), iodine value (IV), Anisidine value (AV), TOTOX value, fatty acid composition and Total carbonyl (TC)

Polar compounds were analyzed according to the AOCS method, Cd11C-93 by column chromatography. Free fatty acid (FFA) content, peroxide value (PV), iodine value of control and fried oil samples were determined as per (AOCS 1989), method No.Ca 5a-40, cd 8–53 and Cd 1-25/93 respectively. Anisidine value and polar compounds were determined by following the AOCS (1989) method No. p2.4 and Cd11C-93 by column chromatography. Analyses were done in triplicates and average values were calculated. Total amount of intermediate polar compounds (peroxides and aldehydes) that result from lipid oxidation was measured as totox number (Wan *et al*., 2009). Fatty acid composition of oils were determined by standard AOCS 1990 methods using gas liquid chromatography (Model HR 1000, Chemito, Chennai, India) with 10% diethylene glycol succinate (DEGS) column.

Statistical analysis

The data analysis, for Duncan multiple comparisons and response optimization were done using STATISTICA stat software release 8.0 package.

Results and Discussion

The role of various flexible as well as rigid packaging materials on the quality and stability of cold extracted virgin coconut oil (CEVCO) and hot extracted virgin coconut oil (HEVCO) at room temperature (RT) (15-35˚C) and 37˚C was investigated (Table 1, 2, 3, 4). Both the CEVCO and HEVCO remained stable during entire storage period upto 12 months. There was no perceptible rancidity or off flavor during the entire one year of storage at RT (15-35°C) and 37˚C. The overall acceptability of soaked Bengal gram dhal fried in stored CEVCO and HEVCO also did not decrease significantly (Table 1, 2).

Off flavour resulting from peroxidation of unsaturated fatty acids is the major cause of spoilage of stored oils (Semwal and Arya 1992). CEVCO and HEVCO were packed in different packaging system to evaluate their stability during storage. In the present investigation, the rate of peroxidation was followed by measuring peroxide value (PV), thiobarbituric acid value (TBA), anisidine value (AV) and free fatty acid (FFA) (Table 1, 2). Initially, the moisture content of CEVCO and HEVCO was 0.05% and 0.06% respectively. After 12 months of storage there was increase in moisture content upto 0.7-0.8% in HEVCO in different packaging system while there was practically no change in CEVCO. Peroxide is considered to be the first product formed in oils by oxidative process. Peroxide value is a good guide to judge about the quality of oil. Initially, PV of CEVCO and HEVCO was 4.95 and 5.65 meq O_2/kg oil, respectively which was significantly ($p \leq 0.05$) increased as a function of storage time in all samples up to 12 months of storage. The increase in PV was found to be significant ($p \leq 0.05$) in CEVCO than HEVCO samples and this increase was not significant

Table 1. Changes in peroxide value (PV; meq O_2/kg fat), free fatty acid (FFA; % lauric acid), thiobarbituric acid (TBA; mg malonaldehyde/kg), iodine value (IV; gm I_2/100 gm), anisidine value (AV) and moisture (%) of the CEVCO in flexible packaging system during storage at room temperature (15-35°C) and 37˚C

Parameters	ST	SP	Packaging system		
			CEVCO (LDPE)	CEVCO (LLDPE)	CEVCO (MP)
PV	15-35°C	0	4.95±0.21a	-	-
		6	9.78±0.04b	7.67±0.11b	5.21±0.12a
		12	15.99±0.43c	12.98±0.02d	9.85±0.15b
	37°C	0	4.95±0.21a	-	-
		6	14.89±0.50c	10.42±0.30d	8.41±0.41b
		12	20.87±0.20e	16.75±0.30c	11.11±0.50d
FFA	15-35°C	0	0.05±0.02a	-	-
		6	0.19±0.01b	0.18±0.01b	0.17±0.01b
		12	0.23±0.01c	0.19±0.02b	0.18±0.01b
	37°C	0	0.05±0.02a	-	-
		6	0.22±0.02c	0.19±0.03b	0.17±0.04b
		12	0.27±0.02c	0.23±0.1c	0.19±0.02b
TBA	15-35°C	0	0.09±0.001a	-	-
		6	0.13±0.01b	0.12±0.01b	0.10±0.01b
		12	0.19±0.01c	0.17±0.01c	0.14±0.01b
	37°C	0	0.09±0.01a	-	-
		6	0.22±0.01b	0.22±0.01b	0.19±0.01b
		12	0.27±0.01c	0.25±0.02c	0.21±0.03c
IV	15-35°C	0	7.53±0.3a	-	-
		6	7.86±0.01a	7.89±0.01a	7.90±0.03a
		12	7.56±0.13a	7.61±0.02a	7.72±0.01a
	37°C	0	7.53±0.3a	-	-
		6	7.42±0.08a	7.41±0.05a	7.40±0.04a
		12	6.85±0.03b	6.91±0.05b	6.95±0.05b
AV	15-35°C	0	3.71±0.4a	-	-
		6	6.98±0.11b	6.78±0.12b	5.98±0.09b
		12	13.32±0.08c	11.43±0.12c	9.98±0.13d
	37°C	0	3.71±0.4a	-	-
		6	10.91±0.08d	9.69±0.07d	8.31±0.06d
		12	16.78±0.03c	12.76±0.01c	9.54±0.05d
OAA	15-35°C	0	8.65±0.11a	-	-
		6	8.47±0.05a	8.64±0.09a	8.53±0.07a
		12	8.01±0.05a	8.12±0.04a	8.14±0.03a
	37°C	0	8.65±0.11a	-	-
		6	8.05±0.13a	8.15±0.01a	8.21±0.11a
		12	7.81±0.15a	7.94±0.10a	7.89±0.04a

ST= Storage temperature; SP= Storage period;
Mean values with the same superscript letters within the same column and row do not differ significantly ($p \leq 0.05$).

Table 2. Changes in peroxide value (PV; meq O_2/kg fat), free fatty acid (FFA; % lauric acid), thiobarbituric acid (TBA; mg malonaldehyde/kg), iodine value (IV; gm I_2/100 gm), anisidine value (AV) and moisture (%) of the CEVCO in rigid packaging system during storage at room temperature (15-35°C) and 37˚C

Parameters	ST	SP	Packaging system		
			CEVCO (PET)	CEVCO (HDPE)	CEVCO (A HDPE)
PV	15-35°C	0	4.95±0.3a	-	-
		6	7.71±0.11b	6.37±0.01a	6.19±0.03a
		12	12.92±0.02d	10.91±0.01cd	9.32±0.02bc
	37°C	0	4.95±0.3a		
		6	11.92±0.05c	9.52±0.06b	9.07±0.04b
		12	16.56±0.02e	12.01±0.04d	11.01±0.05d
FFA	15-35°C	0	0.05±0.01a	-	-
		6	0.17±0.01b	0.16±0.02b	0.16±0.01b
		12	0.19±0.001b	0.19±0.03b	0.18±0.01b
	37°C	0	0.05±0.001a	-	-
		6	0.21±0.01bc	0.17±0.02b	0.17±0.03b
		12	0.25±0.03c	0.23±0.01c	0.12±0.05b
TBA	15-35°C	0	0.09±0.03a	-	-
		6	0.12±0.01b	0.11±0.01b	0.11±0.01b
		12	0.15±0.02b	0.13±0.03b	0.13±0.02b
	37°C	0	0.09±0.03a	-	-
		6	0.18±0.03c	0.16±0.02b	0.15±0.02b
		12	0.22±0.02c	0.19±0.03c	0.19±0.02c
IV	15-35°C	0	7.53±0.03a	-	-
		6	7.52±0.03a	7.53±0.02a	7.52±0.03a
		12	7.51±0.01a	7.52±0.01a	7.50±0.02a
	37°C	0	7.53±0.31a	-	-
		6	7.52±0.11a	7.59±0.20a	7.51±0.32a
		12	6.98±0.21a	7.15±0.32a	7.15±0.63a
AV	15-35°C	0	3.71±0.05a	-	-
		6	5.17±0.01a	5.11±0.01a	5.09±0.03a
		12	9.68±0.02b	9.57±0.02b	8.14±0.04b
	37°C	0	3.71±0.05a	-	-
		6	8.91±0.30b	8.67±0.50b	6.35±0.61b
		12	13.79±0.57c	10.91±0.68c	8.15±0.89b
OAA	15-35°C	0	8.88±0.18a	-	-
		6	8.86±0.08a	8.87±0.02a	8.87±0.06a
		12	8.85±0.07a	8.83±0.05a	8.86±0.08a
	37°C	0	8.88±0.18a	-	-
		6	8.11±0.25a	8.69±0.14a	8.71±0.16a
		12	7.94±0.15b	8.51±0.15a	8.05±0.07a

ST= Storage temperature; SP= Storage period; A HDPE=HDPE Amber; Mean ± SD

($p \leq 0.05$) in MP packed samples as compared to LDPE and LLDPE pouches among flexible packaging materials during 12 months storage. Among the rigid containers the significant ($p \leq 0.05$) increase in PV was more pronounced in PET stored samples as compared to the HDPE and amber HDPE stored ones. It should be noted that the quality of the VCO is significantly affected by the ability of the packaging materials to exclude light and oxygen which further retards oxidative changes. MP and HDPE packaging systems were highly resistant to oxygen transmission (< 1cc/m^2/day) in comparison to the other flexible [LLDPE (OTR 2500cc/m^2/day), LDPE (OTR 7000cc/m^2/day)] and rigid container [PET (OTR 10.82cc/m^2/day)]. Therefore, the formation of peroxides both in CEVCO and HEVCO were slower in MP and HDPE packaging system.

Formation of FFA might be an important measure of rancidity of foods. FFAs are formed due to hydrolysis of triglycerides and may get promoted by reaction of oil with moisture (Shahidi and Wasundara, 2002). Initially, both CEVCO and HEVCO had low free fatty acid (0.05 and 0.04% lauric acid) content. During storage, FFA content was found to increase in all the packaging system studied. FFA value increase was more pronounced in CEVCO samples as compared to HEVCO samples. The rate of hydrolysis reaction was found to be slightly higher in samples stored at 37˚C than the ones stored at room temperatures. The changes in PV and FFA were not large enough to cause perceptible changes in sensory quality of both CEVCO and HEVCO upto one year storage period at RT (15-35˚C) and 37˚C. TBA measure the formation of secondary oxidation products i.e. aldehydes, ketones or carbonyl, which may contribute to off-flavor of oxidized oils (Shahidi and Wanasundara, 2002).

The initial values of TBA and AV in CEVCO and HEVCO were 0.09, 3.71 mg malonaldehyde/kg and 0.08, 4.08 mg malonaldehyde/kg respectively. During storage TBA increased steadily in both CEVCO and HEVCO and in all the packaging system. The rate of increase was slightly higher at 37˚C stored samples as compare to RT stored ones. The formation of secondary oxidation products principally 2-alkenals and 2, 4-alkadienals under storage conditions was also determined by anisidine value and is presented in Table 11, 12. Initial AV in CEVCO and HEVCO was 3.71 and 4.08 respectively. A concomitant increase in AV was observed which was more pronounced in samples stored in flexible packaging system than the ones stored in rigid containers (Table 1, 2). The refractive index of both CEVCO and HEVCO was 1.4550 and did not increase during the entire storage

Table 3. Changes in fatty acid profile (%) of the cold extracted virgin coconut oil (CEVCO) in different flexible (LDPE, LLDPE, MP) and rigid packaging (PET, HDPE, AHDPE) material during storage at 37˚C

Packaging system	ST	SP	Caproic	Caprylic	Capric	Lauric	Myristic	Palmitic	Stearic	Oleic	Linoleic
CEVCO	37ºC	0 M	0.53±0.02a	6.20±0.12a	6.25±0.25a	51.84±0.55a	17.01±1.25a	8.05±0.11a	3.02±0.15a	5.26±0.36a	1.27±0.25a
CEVCO (LDPE)		12 M	0.53±0.01a	6.22±0.21a	6.24±0.36a	51.83±0.61a	17.02±1.31a	8.08±0.12a	3.07±0.14a	6.30±0.15b	0.71±0.05b
CEVCO (LLDPE)			0.53±0.03a	6.21±0.11a	6.26±0.15a	51.85±0.24a	16.88±1.11b	7.99±0.14a	3.03±0.11a	6.09±0.12b	0.96±0.04b
CEVCO (MP)			0.54±0.05a	6.20±0.14a	6.27±0.24a	51.86±0.17a	17.03±1.01a	8.11±0.16a	3.06±0.14a	5.34±0.14a	1.05±0.01a
CEVCO (PET)			0.53±0.02a	5.20±0.15a	5.24±0.11a	50.83±1.11b	18.89±1.12b	8.42±0.23a	2.92±0.12b	6.95±0.11b	0.72±0.001b
CEVCO (HDPE)			0.52±0.03a	5.21±0.11a	5.26±0.15a	50.77±1.14a	18.70±1.14b	8.91±0.24b	3.61±0.14a	6.21±0.14b	0.81±0.01b
CEVCO (A HDPE)			0.51±0.01a	5.21±0.15a	5.25±0.12b	50.82±1.13a	18.91±1.21b	9.43±0.15b	3.60±0.21a	5.18±0.16a	1.01±0.02a

ST=Storage temperature; SP= Storage period; A HDPE= HDPE Amber; Mean ± SD

Table 4. Changes in fatty acid profile (%) of the hot extracted virgin coconut oil (HEVCO) in different flexible and rigid packaging system during storage at 37˚C

Packaging system	ST	SP	Caproic	Caprylic	Capric	Lauric	Myristic	Palmitic	Stearic	Oleic	Linoleic
HEVCO	37ºC	0 M	0.32±0.04a	6.27±0.11a	5.50±0.19a	51.01±0.15a	18.13±1.00a	9.22±0.17a	3.01±0.01a	5.21±0.15a	1.33±0.04a
HEVCO (LDPE)		12 M	0.33±0.02a	6.25±0.36a	5.52±0.58a	51.01±0.13a	18.14±1.02a	9.31±0.19a	2.25±0.41b	6.32±0.17b	0.80±0.01b
HEVCO (LLDPE)			0.33±0.07a	6.26±0.22a	5.51±0.47a	51.02±0.17a	18.12±1.04a	9.28±0.18a	2.11±0.24b	6.30±0.71b	0.99±0.02b
HEVCO (MP)			0.32±0.08a	6.27±0.15a	5.50±0.36a	51.03±0.18a	18.15±1.05a	9.25±0.14a	3.05±0.74a	5.35±0.54a	1.07±0.01a
HEVCO (PET)			0.42±0.02b	5.12±0.13b	5.21±0.15a	52.15±1.10b	19.50±1.23b	8.44±0.54b	2.30±0.26b	5.88±0.18a	0.91±0.02b
HEVCO (HDPE)			0.43±0.03b	5.12±0.14b	5.22±0.17a	51.86±1.17a	19.21±1.22b	8.25±0.26b	2.39±0.28b	6.38±0.14b	0.99±0.03b
HEVCO (A HDPE)			0.44±0.05b	5.13±0.15b	5.23±0.17a	52.17±1.14b	19.53±1.15b	8.46±0.24b	2.38±0.23b	5.49±0.19a	1.07±0.01a

ST=Storage temperature; SP= Storage period; A HDPE= HDPE Amber; Mean ± SD

period both in flexible and rigid packaging system. Initially, the IV of CEVCO and HEVCO were 7.91 gm I_2/100gm and 6.89 gm $_{I2}$/100gm respectively. In both CEVCO and HEVCO, there was a decrease of less than 1 unit in IV during the entire storage period of 12 months. Initially, the OAA of soaked bengal gram dhal fried in VCO was not significantly ($p \leq 0.05$) different, but tended to decrease when fried in stored samples (Table 1, 2).

Autoxidation of vegetable oils affects their fatty acid composition, as polyunsaturated fatty acids are oxidized faster than saturated and monounsaturated fatty acids (Swern, 1964). The changes in fatty acid composition in CEVCO and HEVCO packed in different flexible and rigid packaging systems and stored at RT (15-35˚C) and 37˚C are given in Table 3, 4. The major fatty acid of VCO was lauric acid (51-52%) and did not change during entire storage period of 12 months. However, linoleic acid was slightly decreased during storage both in CEVCO and HEVCO.

Conclusion

In the present study the physicochemical parameters analyzed in CEVCO and HEVCO packed in different packaging systems. At the beginning of the study all the physicochemical parameters were within the limits established by the legislation, but vary during the 12 months of storage (PFA 1954). The acidification and oxidative rancidity of the CEVCO and HEVCO increased after 12 months of storage. The degree of unsaturation tends to decrease as the expiry date becomes closer and although the percentages of fatty acid remain constant until 12 months of storage. It is evident that both the oils viz. CEVCO and HEVCO remained in stable and acceptable condition for 12 months in RT (15-35°C) and 37˚C. The rate of lipid peroxidation was found to significantly ($p \leq 0.05$) higher in CEVCO as compared HEVCO. Among the packaging material studied, MP and HDPE provided the best protection towards oxidation and dhal fried in these oil samples

were rated higher sensory acceptable score. The refractive index, iodine value and moisture content of both CEVCO and HEVCO were not increased during the entire storage period both in flexible and rigid packaging system. There was significant ($p \leq 0.05$)decrease in OAA of bengal gram dhal fried in stored CEVCO and HEVCO samples in flexible as well as rigid packaging systems.

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