Storage stability of packed coconut oil blends with other vegetable oils

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The storage stability of the packed coconut oil blends mainly depends on the barrier properties of the packing material against oxygen, light and temperature. The storage stability of the packed coconut oil blends can be improved by the selection of a suitable packing material and the storage condition.

Abstract

Evaluation of storage stability of packed coconut oil blends with other vegetable oils with regard to packaging material, storage period, and storage condition was conducted. The blends of coconut oil (CNO) were prepared with sunflower oil, rice bran oil, safflower oil, groundnut oil, sesame oil and palm oil. The blends were packed in pouches of two different packing materials (nylon based and foil laminate) and stored at two different temperatures and relative humidity conditions (27 °C / 65% RH and 38 °C / 90% RH) for 120 days. Colour, peroxide value (PV), free fatty acid value (FFA) and moisture content of the blends were analyzed at regular intervals to monitor bleaching of colour, oxidation, hydrolysis and moisture pick-up during storage. Initial values of CNO blends for colour (2.3- 16.6 Lovibond units), PV (1.03- 2.98 meqO_2/Kg), FFA (0.08 - 2.1%) and moisture content (0.016 - 0.039%) changed during storage. The study showed that the blends packed in nylon based co-extruded film and stored at 27 °C / 65% RH and 38 °C/90% RH recorded higher PV (32.1 and 117.9 meqO_2/Kg), FFA (1.56 and 1.85 %) and moisture content (0.071- 0.186%) respectively, than the blends packed in foil laminated packing material. The foil laminated packing material provided greater protection to the CNO blends stored at 27 °C / 65% RH and 38 °C / 90% RH against oxidation (4.33 and 6.03 meqO_2/Kg), hydrolysis (1.53 and 1.51%) and moisture pick-up (0.034 and 0.037%) respectively. Oxidation, hydrolysis and moisture pick-up was more rapid for the packed blends stored at 38 °C/ 90%RH. The observed results indicated that foil laminated packing material and storage condition of 27 °C/65%RH provided excellent storage stability to packed coconut oil blends.

Introduction

Coconut oil derived from the nuts of *Cocos nucifera*, a tropical plant serves as a major source of dietary fats in southern parts of India, mainly Kerala and coastal regions of Karnataka, Tamilnadu and Andhra Pradesh [1]. In these regions, consumers may not prefer other vegetable oils for consumption due to the preferred flavour of coconut

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oil that is being traditionally consumed in these parts. Thus other vegetable oils are being made available to the coconut oil consumers through blending of these oils with coconut oil. Coconut oil contains 91 % of saturated fatty acids (SFA) and is deficient of tocopherols. But, almost all other vegetable oils are rich in monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA) and tocopherols [2]. Blending of other vegetable oils with coconut oil will enable the coconut oil consumers to get the health improving constituents like MUFA, PUFA, tocopherols, tocotrienols, phytosterols, oryzanol and lignans from other vegetable oils [3].

Rancidity due to oxidation and hydrolysis is a major problem during the storage of oil blends [4]. Since, oxidation has been recognized as the major problem of edible oil blends during storage, the storage stability evaluation of packed oil blends is of much relevance. The oxidation of oil blends leads to deteriorative changes in physical, chemical, sensory and nutritional properties and results in inferior quality, reduced shelf life of blends and leads to consumer dissatisfaction [5, 6]. Thus, the appropriate knowledge about storage stability of oil blend is necessary for the successful development and marketing of these blends.

Hence, selection of a suitable packing material helps to minimize the factors that affect the stability of oil blends. The current study was undertaken to evaluate the storage stability of coconut oil blends and the effect of different factors on the storage stability which included (i) type of packing material (nylon based coextruded and foil laminated), (ii) storage temperature and relative humidity (27 °C/ 65% RH and 38 °C/ 90% RH), (iii) storage period (0-120 days) and (iv) natural antioxidants (tocopherols, oryzanol and lignans).

Materials and methods

Oils: Refined, bleached and deodorized vegetable oils i.e. rice bran oil (RBO), sunflower oil (SFO) and safflower oil (SAFO) and unrefined oils i.e. coconut (CNO), groundnut (GNO) and sesame (SESO) were purchased from the local market of Mysore city and used for blending.

Chemicals: All chemicals and solvents used were of analytical reagent grade.

Packing Materials: a) Nylon (polyamide) based co-extruded film (LLDPE/BA/PA/BA/mettallocine) packing material (PA) and b) Foil laminate (12 µm PET/9 µm aluminium foil / 38 µm LDPE) packing material (FL) were selected for packing the oil blends. The oxygen transmission rate (OTR) and water vapor transmission rate (WVTR) was determined as per BIS and ASTM methods (7, 8).

Coconut oil blend preparation: Coconut oil consumers prefer strong coconut oil aroma in their food. Therefore, the blends for them were prepared by using CNO. The basis of selection of seven blends for coconut oil consumers was a combination of three factors: (i) Presence of strong coconut oil aroma, (ii) Presence of adequate amounts of monounsaturates, polyunsaturates and natural antioxidants, (iii) Lower cost of the blend when compared to CNO only. The seven blends selected for coconut oil consumers were 20% CNO + 80% SFO, 50% CNO + 50% RBO, 80% CNO + 20% SAFO, 80% CNO + 20% SESO, 50% CNO + 50% GNO, 50% CNO + 50% PO, 20% CNO + 80% PO. These blends of coconut oil (15 Kg batch) were prepared on pilot scale by placing CNO and other oil in the desired ratio and mixing in a kettle as per patented procedure [9]. The prepared blends were immediately taken for packing while some amount of the blend was taken to analyze the initial quality parameters like PV, FFA, moisture content and colour.

Packaging and storage studies of oil blends: The oil blends (200 ml) were packed in 16 × 10 cm uniform pouches (PA and FL), in such a way so that the air contact be minimum (minimum head space) by driving out air from the pouch as far as possible manually. The pouches were stored in two separate humidity cabinet adjusted to two storage conditions i.e. room conditions (27 °C / 65% RH) and accelerated condition (38 °C and 90% RH). The stored samples were withdrawn at fixed intervals. Withdrawal of samples during storage period: CNO blends stored in nylon based pouches at 38 °C and 90% RH were withdrawn at every 15th day interval. CNO blends stored in nylon based pouches at 27 °C and 65% RH were withdrawn at every 30th day interval. CNO blends stored in foil laminate based pouches at 38 °C and 90% RH were withdrawn at every 30th day interval. CNO blends stored in foil laminate based pouches at 27 °C and 65% RH were withdrawn at every 60th day interval. Each withdrawal of the sample was done in duplicate

and evaluated for (i) oxidation (PV), (ii) bleaching of colour (colour), (iii) hydrolysis (FFA) and (iv) moisture pick up (moisture content).

Analytical methods: Peroxide value (PV), free fatty acid value (FFA), unsaponifiable matter and fatty acid composition of the oil blends were analysed according to AOCS method Nos. Cd 8-53 (1998) and Ca 5a-40 (1998), Ca 6a-40 , Ce 1-62 respectively [10]. Colour of the oil blends were determined by using lovibond tintometer in 1" cell and expressed as 5R+Y lovibond units. Moisture content of the oil blends was analyzed according to BIS method No. 548 (1964) by placing 10 g of oil blend in a hot air oven adjusted to the temperature of 100 ±1°C for 1h [11]. Oryzanol content in RBO and its blends was determined by spectrophotometric method [12].

Tocopherol estimation: The total tocopherol content was determined by using IUPAC Method No.2.301, 1987 [13]. Analysis of lignans in SESO and its blends was performed by HPLC (model LC-10A VP Shimadzu corporation, Kyoto, Japan) equipped with a UV-detector (290 nm) on a C18 phenomenex column (250 mm length x 4.6 mm i.d.) using 70% methanol as the mobile phase according to Kamal Eldin and Appelqvist [14].

Results and discussion

General characteristics of starting oils and its blends: The general characteristics of the vegetable oils and oil blends are given in Table 1. The fatty acid composition of CNO showed 92.4% of SFA, 6.2% of MUFA and 1.4% of PUFA. The MUFA content of the other vegetable oils were in the range of 29.2% for SAFO to 43.7% for SFO and the PUFA content of the other vegetable oils were in the range of 10.4% for PO to 56.3% for SAFO. The CNO blends had MUFA in the range of 8.3% for CNO+SAFO blend to 36.3% for CNO+SFO blend and PUFA in the range of 4.4% for CNO+PO (1:1) blend to 35.6% for CNO+SFO blend. The FFA content of the vegetable oils was in the range of 0.03% for SFO to 1.5% for SESO. The observed FFA content of the

Table 1. General characteristics of starting oils and its blends

Parameters	CNO	SFO	RBO	SAFO	SESO	GNO	PO	CNO:SFO (1:4)	CNO:RBO (1:1)	CNO:SAFO (4:1)	CNO:SESO (4:1)	CNO:GNO (1:1)	CNO: PO (1:1)	CNO: PO (1:4)
C8:0	7.0	--	--	--	--	--	--	1.2	3.9	6.0	5.6	3.5	1.3	3.7
C10:0	5.4	--	--	--	--	--	--	1.1	2.9	3.9	4.3	2.9	1.1	2.7
C12:0	48.9	--	--	--	--	--	0.2	10.3	26.0	39.3	39.1	26.5	10.5	25.0
C14:0	20.2	--	0.4	0.3	--	--	1.1	4.7	11.8	17.5	17.5	11.8	5.4	11.2
C16:0	8.4	6.3	22.9	11.9	10.3	14.0	42.6	7.4	16.3	8.8	9.7	12.2	35.5	26.2
C18:0	2.5	3.0	1.8	2.3	5.8	3.8	3.8	3.4	2.6	1.9	3.5	4.1	3.5	3.5
C18:1	6.2	43.7	42.5	29.2	42.9	41.9	41.9	36.3	23.9	8.3	12.3	24.8	34.4	23.3
C18:2	1.4	47.0	30.5	55.9	41.0	34.7*	10.4	35.6	12.6	14.3	8.0	14.2	8.3	4.4
C18:3	--	--	1.4	0.4	--	1.0	--	--	--	--	--	--	--	--
C20:0	--	--	0.5	--	--	1.2	--	--	--	--	--	--	--	--
C22:0	--	--	--	--	--	3.4	--	--	--	--	--	--	--	--
MUFA	6.2	43.7	42.5	29.2	42.9	41.9	41.9	36.3	23.9	8.3	12.3	24.8	34.4	23.3
PUFA	1.4	47.0	31.0	56.3	41.0	35.7	10.4	35.6	12.6	14.3	8.0	14.2	8.3	4.4
SAFA	92.4	9.3	25.1	14.5	16.1	22.4	47.7	28.1	63.5	77.4	79.7	61.0	57.3	72.3
FFA (% as oleic)	1.15	0.03	0.16	0.10	1.53	0.85	0.29	0.28	0.69	0.98	1.26	1.47	0.75	0.49
PV (meq O2/Kg oil)	0.00	5.97	1.97	8.92	0.98	0.99	0.99	1.96	1.03	2.98	1.95	1.80	1.25	1.96
Colour (5R+Y)	2.5	4.0	11.5	2.2	25.0	12.0	17.5	3.3	6.0	2.3	5.0	8.0	10.5	16.5
Unsap. matter (%)	0.15	0.88	3.00	0.55	1.58	0.60	0.30	0.76	1.34	0.25	0.45	0.50	0.30	0.40
Tocopherol (mg/100g oil)	2.9	49.7	80.0	62.4	57.5	50.7	73.8	38.4	38.7	13.0	11.1	24.9	37.4	58.2
Oryzanol (%)	--	--	0.28	--	--	--	--	--	0.14	--	--	--	--	--
Lignans (%)	--	--	--	--	1.30	--	--	--	--	--	0.24	--	--	--

*MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acid, SAFA: Saturated fatty acid, FFA: Free fatty acid, PV: Peroxide value, CNO: Coconut oil, SFO: Sunflower oil, RBO: Rice bran oil, SAFO: Safflower oil, SESO: Sesame oil, GNO: Groundnut oil, PO: Palm oil

CNO blends were found to be similar with the expected FFA content calculated by taking in to account the respective FFA percentage of the constituent oils in the blend. This indicated that there was no FFA liberation during blending. The PV of the vegetable oils was d" 10 meq O_2 / Kg oil indicating that the oils used for blending were in good condition and properly processed. The PV of the CNO blends showed no significant changes due to oxidation during blending process, indicating that the blending procedure used was efficient to control the oxidation during processing. The colour of the vegetable oils was in the range of 2.2 Lovibond units for SAFO to 25.0 for SESO. The colour of the CNO blends was in the range of 2.3 Lovibond units CNO+ SAFO blend to 16.5 Lovibond units for CNO: PO (1:4) blend. CNO contained very less unsaponifiable matter (0.15 %) while RBO contained high unsaponifiable matter (3.0 %) among all the vegetable oils used. The major antioxidants present in all the vegetable oils and their blends were total tocopherols. CNO contained 3.0 mg tocopherols / 100g oil and the total tocopherols content of the other vegetable oils was in the range of 49.7 mg / 100g oil for SFO to 80.0 mg / 100g oil for RBO. In CNO blends the total tocopherols were in the range of 11.1 mg / 100g oil for CNO+SESO blend to 58.2 mg / 100g oil for CNO+PO (1:4) blend. Other natural antioxidant like oryzanol was present in RBO (0.28%) and in CNO+RBO blend (0.14%). The lignans were the major antioxidants present in SESO (1.3 %) and in CNO+SESO blend (0.24 %). The overall characteristics of the blends indicated that the MUFA, PUFA and natural antioxidants were incorporated in different levels into the coconut oil through blending.

Generally oil needs good O_2 barrier coupled with a good sealant layer even when the contamination of the sealing area occurred. Nylon

Table 2. Storage behavior of coconut oil blends packed in PA based packaging material and storage at 38 C/90% RH.

Parameters	CNO blends/ Ratios	Blends stored at 38 C /90% RH Days of Storage							
		0	15	30	45	60	75	90	120
Moisture (%)*	CNO+SFO(1:4)	0.024±0.003^{a}	0.059±0.003^{b}	0.061±0.004^{b}	0.091±0.001^{c}	0.086±0.007^{c}	0.097±0.001^{c}	0.107±0.001^{d}	0.058±0.001^{b}
	CNO+RBO(1:1)	0.027±0.002^{a}	0.099±0.004^{b}	0.087±0.008^{c}	0.114±0.001^{d}	0.131±0.000^{e}	0.106±0.002^{cf}	0.141±0.002^{f}	0.091±0.001^{g}
	CNO+SAFO(4:1)	0.036±0.002^{a}	0.088±0.001^{b}	0.111±0.006^{c}	0.134±0.008^{d}	0.156±0.001^{e}	0.171±0.011^{f}	0.186±0.011^{g}	0.114±0.002^{c}
	CNO+SESO(4:1)	0.039±0.004^{a}	0.096±0.004^{b}	0.112±0.004^{c}	0.129±0.004^{d}	0.171±0.009^{e}	0.176±0.001^{e}	0.181±0.007^{e}	0.128±0.001^{d}
	CNO+GNO(1:1)	0.022±0.002^{a}	0.079±0.000^{b}	0.087±0.003^{c}	0.117±0.008^{d}	0.144±0.001^{e}	0.147±0.002^{e}	0.150±0.000^{e}	0.099±0.000^{f}
	CNO+PO (1:1)	0.018±0.001^{a}	0.083±0.000^{b}	0.095±0.002^{b}	0.132±0.006^{c}	0.137±0.000^{cd}	0.154±0.001^{de}	0.171±0.023^{e}	0.099±0.001^{b}
	CNO+PO (1:4)	0.016±0.002^{a}	0.084±0.004^{b}	0.084±0.001^{b}	0.112±0.009^{c}	0.108±0.008^{c}	0.128±0.001^{d}	0.147±0.001^{e}	0.083±0.004^{b}
Colour (5R+Y)**	CNO+SFO(1:4)	3.3±0.000^{a}	3.5±0.283^{a}	3.4±0.212^{a}	3.3±0.000^{a}	3.4±0.071^{a}	3.5±0.141^{a}	3.6±0.071^{a}	3.6±0.141^{a}
	CNO+RBO(1:1)	6.0±0.000^{a}	6.1±0.0.071^{a}	6.1±0.071^{a}	6.0±0.000^{a}	6.1±0.071^{a}	6.0±0.000^{a}	6.0±0.000^{a}	6.0±0.000^{a}
	CNO+SAFO(4:1)	2.5±0.000^{a}	2.5±0.071^{a}	2.6±0.071^{a}	2.5±0.071^{a}	2.6±0.071^{a}	2.5±0.000^{a}	2.6±0.000^{a}	2.6±0.000^{a}
	CNO+SESO(4:1)	5.5±0.071^{a}	5.5±0.000^{a}	5.5±0.000^{a}	5.5±0.000^{a}	5.5±0.000^{a}	5.5±0.000^{a}	5.5±0.000^{a}	5.5±0.071^{a}
	CNO+GNO(1:1)	7.5±0.141^{a}	7.5±0.000^{a}	7.5±0.000^{a}	7.5±0.000^{a}	7.6±0.071^{a}	7.6±0.071^{a}	7.6±0.071^{a}	7.6±0.071^{a}
	CNO+PO (1:1)	10.5±0.000^{a}	10.5±0.000^{a}	10.6±0.141^{a}	10.6±0.071^{a}	10.6±0.000^{a}	10.6±0.000^{a}	10.6±0.000^{a}	10.6±0.071^{a}
	CNO+PO (1:4)	15.5±0.000^{a}	15.5±0.000^{a}	15.5±0.000^{a}	15.3±0.500^{a}	15.7±0.000^{a}	15.6±0.000^{a}	15.4±0.000^{a}	15.4±0.141^{a}
Free fatty acid (%) ***	CNO+SFO(1:4)	0.27±0.007^{a}	0.27±0.000^{a}	0.30±0.000^{b}	0.29±0.000^{c}	0.32±0.000^{d}	0.32±0.000^{d}	0.37±0.000^{a}	0.47±0.000^{f}
	CNO+RBO(1:1)	0.69±0.014^{a}	0.70±0.014^{ab}	0.71±0.014^{b}	0.71±0.014^{b}	0.74±0.000^{c}	0.80±0.000^{d}	0.74±0.000^{d}	0.88±0.000^{a}
	CNO+SAFO(4:1)	0.98±0.014^{a}	1.03±0.00^{b}	1.04±0.000^{b}	1.03±0.000^{b}	1.06±0.000^{c}	1.20±0.014^{d}	1.33±0.000^{e}	1.34±0.000^{e}
	CNO+SESO(4:1)	1.26±0.014^{a}	1.32±0.000^{b}	1.36±0.000^{a}	1.33±0.000^{b}	1.43±0.007^{d}	1.44±0.000^{d}	1.53±0.007^{e}	1.65±0.007^{f}
	CNO+GNO(1:1)	1.47±0.014^{a}	1.53±0.000^{b+}	1.65±0.000^{c}	1.62±0.000^{c}	1.70±0.007^{d}	1.72±0.049^{d}	1.85±0.014^{e}	1.98±0.007^{f}
	CNO+PO (1:1)	0.75±0.014^{a}	0.80±0.000^{a}	0.78±0.007^{a}	0.78±0.000^{a}	0.85±0.000^{a}	0.90±0.000^{a}	0.97±0.007^{a}	1.10±0.000^{a}
	CNO+PO (1:4)	0.49±0.000^{a}	0.58±0.007^{a}	0.59±0.007^{a}	0.63±0.000^{a}	0.69±0.000^{a}	0.68±0.007^{a}	0.74±0.000^{a}	0.88±0.000^{a}
Peroxide value (meq O2/Kg oil)	CNO+SFO(1:4)	1.96±0.007	17.41±0.516^{c}	33.10±0.021^{c}	55.00±0.049^{c}	73.65±0.247^{c}	97.60±0.552^{c}	117.9±0.290^{c}	139.3±0.44^{c}
	CNO+RBO(1:1)	1.03±0.049	2.95±0.035^{c}	3.00±0.007^{c}	3.01±0.000^{c}	4.00±0.000^{c}	6.00±0.007^{c}	7.00±0.049^{c}	7.57±0.665^{c}
	CNO+SAFO(4:1)	2.98±0.042	3.96±0.007^{c}	3.96±0.021^{c}	4.00±0.014^{c}	4.00±0.007^{c}	4.00±0.007^{c}	4.00±0.304^{c}	4.03±0.000^{c}
	CNO+SESO(4:1)	1.95±0.035	3.00±0.007^{c}	2.00±0.014^{c}	3.00±0.007^{c}	3.00±0.014^{c}	3.00±0.184^{c}	3.00±0.000^{c}	3.01±0.014^{c}
	CNO+GNO(1:1)	1.80±0.007	3.00±0.000^{c}	3.98±0.007^{c}	3.00±0.007^{c}	4.20±0.269^{c}	4.20±0.014^{c}	4.20±0.014^{c}	5.96±0.608^{c}
	CNO+PO (1:1)	1.25±0.007	2.00±0.000^{c}	3.00±0.007^{c}	3.01±0.000^{c}	3.00±0.007^{c}	4.00±0.042^{c}	4.50±0.014^{c}	4.42±0.608^{c}
	CNO+PO (1:4)	1.96±0.000	4.00±0.014^{c}	5.50±0.007^{c}	7.00±0.014^{c}	10.00±0.007^{c}	13.00±0.035^{c}	14.00±0.113^{c}	16.05±0.16^{c}

*Values with different superscript in the row indicates p value is <0.01, considered significant changes in moisture content as compared to initial moisture.
**Values with different superscript in the row indicates p value is <0.05, considered significant changes in free fatty acid as compared to initial free fatty acid value.
***Values with different superscript in the row indicates p value is <0.01, considered significant changes in peroxide as compared to initial peroxide value.
Values in the row with same superscript indicate p value is >0.05, considered that there is no significant changes.

is a good O_2 barrier and mettallocine poly ethylene is a good sealable material. Hence 5 layer nylon based coextruded material which is the cheapest satisfying both the requirement was selected. To estimate the maximum shelf life of the oil, practically zero barrier material aluminium foil laminate was selected. The two storage conditions of 90% RH/38 °C and 65% RH/27 °C were selected as per BIS which simulate the conditions of coastal regions and average climatic conditions of other places [15].

Storage behavior of coconut oil blends packed in nylon based packaging material at two storage conditions: Looking into the product need, nylon based laminate (PA) with OTR of 44CC/Sqm/day/atm under 65% RH/27 °C and WVTR of 4.8 CC/Sqm/day/atm under 90 % RH gradient at 38 °C and foil laminate of OTR <0.2 CC/Sqm/day/atm and practically nil WVTR for short term and long term storage respectively were selected for storage studies. The storage behavior (moisture pickup, colour, free fatty acid and peroxide value) of CNO blends packed at PA and stored at 38 °C / 90% RH and 27 °C / 65% RH during the storage period of 0-120 days is given in Table 2 and 3. The moisture content of the CNO blends stored at 38 °C / 90% RH increased with the storage period and the maximum moisture pickup was at 90 days of storage and dropped during later storage days. The CNO+SAFO blend showed highest moisture pickup (0.036 - 0.186%) as compared to other CNO blends stored under the same conditions. The CNO+SFO blend showed the lowest moisture pickup (0.024 - 0.107%) as compared to the other CNO blends stored under the same conditions. But, the same CNO blends packed with the same packing material (PA) and stored at 27 °C / 65% RH showed no moisture pickup during the storage. This indicated that the storage condition of 27 °C / 65% RH was suitable to prevent the moisture pickup during storage of CNO blends packed with nylon based packing material (PA).

The colour of the CNO blends packed in nylon based package during the storage of 0-120 days showed little or no change during the storage under both conditions i.e. 38 °C / 90% RH and 27 °C / 65% RH. This indicated that the bleaching of colour of the CNO blends did not happen under both the storage conditions. This may be due to nontransmitant white pigmented packaging material offering protection against light.

The FFA content of the CNO blends stored at 38 °C / 90% RH showed constant increase with the storage period. The CNO + SFO blend showed minimum rise (0.28 - 0.47%) in FFA content as compared

Table 3. Storage behavior of coconut oil blends packed in PA based packaging material and storage at 27 C /65% RH.

Parameters	CNO Blends/ ratios	Blends Stored at 27 °C /65% RH Days of Storage				
		0	30	60	90	120
Moisture (%)*	CNO+SFO(1:4)	0.024±0.003^{a}	0.013±0.000^{b}	0.012±0.000^{b}	0.012±0.008^{b}	0.010±0.004^{b}
	CNO+RBO(1:1)	0.027±0.002^{a}	0.022±0.002^{a}	0.011±0.001^{b}	0.011±0.004^{b}	0.009±0.002^{b}
	CNO+SAFO(4:1)	0.036±0.002^{a}	0.029±0.028^{a}	0.015±0.001^{a}	0.015±0.005^{a}	0.017±0.001^{a}
	CNO+SESO(4:1)	0.039±0.004^{a}	0.025±0.000^{b}	0.014±0.002^{c}	0.014±0.002^{c}	0.021±0.004^{d}
	CNO+GNO(1:1)	0.022±0.002^{a}	0.018±0.001^{b}	0.010±0.001^{c}	0.010±0.002^{c}	0.037±0.001^{d}
	CNO+PO (1:1)	0.018±0.001^{a}	0.012±0.001^{a}	0.012±0.006^{a}	0.012±0.001^{a}	0.015±0.003^{a}
	CNO+PO (1:4)	0.016±0.002^{a}	0.015±0.002^{a}	0.018±0.001^{a}	0.018±0.001^{a}	0.019±0.003^{a}
Colour (5R+Y)	CNO+SFO(1:4)	3.3±0.000^{a}	3.4±0.071^{a}	3.5±0.071^{a}	3.5±0.071^{a}	3.5±0.071^{a}
	CNO+RBO(1:1)	6.0±0.000^{a}	6.0±0.000^{a}	6.0±0.000^{a}	6.0±0.000^{a}	6.0±0.000^{a}
	CNO+SAFO(4:1)	2.5±0.000^{a}	2.4±0.071^{a}	2.4±0.071^{a}	2.5±0.000^{a}	2.5±0.000^{a}
	CNO+SESO(4:1)	5.5±0.071^{a}	5.5±0.000^{a}	5.5±0.000^{a}	5.5±0.000^{a}	5.5±0.071^{a}
	CNO+GNO(1:1)	7.5±0.141^{a}	7.5±0.141^{a}	7.5±0.071^{a}	7.5±0.000^{a}	7.5±0.000^{a}
	CNO+PO (1:1)	10.5±0.000^{a}	10.6±0.071^{a}	10.6±0.071^{a}	10.6±0.071^{a}	10.6±0.071^{a}
	CNO+PO (1:4)	15.5±0.000^{a}	15.5±0.212^{a}	15.5±0.000^{a}	15.5±0.071^{a}	15.5±0.000^{a}
Free fatty acid (%)**	CNO+SFO(1:4)	0.27±0.007^{a}	0.27±0.000^{a}	0.27±0.007^{a}	0.27±0.007^{a}	0.31±0.000^{b}
	CNO+RBO(1:1)	0.69±0.014^{a}	0.70±0.014^{a}	0.72±0.000^{a}	0.72±0.007^{a}	0.73±0.000^{a}
	CNO+SAFO(4:1)	0.98±0.014^{a}	0.98±0.000^{ab}	1.01±0.000^{abc}	1.02±0.007^{cd}	1.03±0.000^{cd}
	CNO+SESO(4:1)	1.26±0.014^{a}	1.26±0.007^{a}	1.28±0.000^{a}	1.29±0.007^{a}	1.33±0.000^{a}
	CNO+GNO(1:1)	1.47±0.014^{a}	1.46±0.000^{ab}	1.49±0.007^{ab}	1.56±0.007^{c}	1.55±0.014^{c}
	CNO+PO (1:1)	0.75±0.014^{a}	0.74±0.000^{ab}	0.77±0.000^{abc}	0.78±0.007^{ac}	0.78±0.000^{ac}
	CNO+PO (1:4)	0.49±0.000^{a}	0.52±0.000^{ab}	0.53±0.007^{abc}	0.52±0.007^{abc}	0.57±0.014^{d}
Peroxide value (meq O_2/Kg oil)***	CNO+SFO(1:4)	1.96±0.007^{a}	7.00±0.064^{b}	15.00±0.049^{c}	32.10±0.007^{d}	29.43±0.601^{e}
	CNO+RBO(1:1)	1.03±0.049^{a}	2.00±0.021^{b}	3.00±0.007^{c}	3.00±0.021^{c}	2.01±0.021^{b}
	CNO+SAFO(4:1)	2.98±0.042^{a}	3.00±0.000^{ab}	3.00±0.007^{ab}	4.00±0.014^{c}	4.04±0.028^{c}
	CNO+SESO(4:1)	1.95±0.035^{a}	2.00±0.007^{a}	2.00±0.000^{a}	2.00±0.000^{a}	2.01±0.064^{a}
	CNO+GNO(1:1)	1.80±0.007^{a}	2.00±0.000^{b}	2.00±0.007^{b}	2.50±0.000^{c}	1.98±0.007^{d}
	CNO+PO (1:1)	1.25±0.007^{a}	2.00±0.000^{b}	2.00±0.021^{b}	3.00±0.021^{c}	2.52±0.007^{d}
	CNO+PO (1:4)	1.96±0.000^{a}	3.00±0.014^{b}	4.00±0.007^{c}	5.00±0.014^{d}	5.95±0.184^{e}

*Values with different superscript in the row indicates p value is <0.01, considered significant changes in moisture content as compared to initial moisture.

**Values with different superscript in the row indicates p value is <0.05, considered significant changes in free fatty acid as compared to initial free fatty acid value.

***Values with different superscript in the row indicates p value is <0.001, considered significant changes in peroxide as compared to initial peroxide value.

Values in the row with same superscript indicate p value is >0.05, considered that there is no significant changes.

to the other CNO blends. The unrefined oil (SESO and GNO) containing blends, CNO + GNO and CNO + SESO showed highest rise in FFA content (1.47 - 1.98 % and 1.26 - 1.65 %) respectively among all the other CNO blends stored under the same storage conditions. This was because of the presence of high initial FFA content of the unrefined oils. The same CNO blends packed in the same packing material and stored at 27 °C / 65% RH showed no or little rise in FFA content, thus indicating the absence of any hydrolytic reaction during the storage of CNO blends at 27 °C / 65% RH.

The CNO blends showed a constant rise in peroxide value (PV) during the storage under 38 °C / 90% RH for 120 days. The peroxide development was maximum (1.96 - 139.3 meq O_2 / Kg of oil) for CNO+SFO blend. This was because of the presence of large amounts of PUFA and MUFA in the blend. But, the same blend packed in the same packing material and stored at 27 °C / 65% RH showed moderate increase in the peroxide development (1.96 - 32.10 meq O_2 / Kg of oil). This is due to high storage temperature and more moisture in the products. The CNO+PO (1:4) blend stored at 38 °C / 90% RH showed rise in the peroxide development (1.96 - 16.05 meq O_2 / Kg of oil) but the same blend stored at 27 °C / 65% RH showed a moderate peroxide development of 1.96 - 5.95 meq O_2/ Kg of oil. The peroxide development was minimum (1.95 - 3.01 meq O_2/ Kg of oil) for CNO + SESO blend. The other CNO blends stored at 38 °C / 90% RH showed peroxide development of less than 6 meq O_2 / Kg of oil and less than 4.5 meq O_2 / Kg of oil when stored at 27 °C / 65 % RH.

Storage behavior of coconut oil blends packed in foil laminated packaging material at two storage conditions: The storage behavior (moisture pickup, colour, free fatty acid and peroxide value) of CNO blends packed in foil laminated packing (FL) material and stored at 38 °C / 90% RH and 27 °C / 65% RH during the period of 0-120 days is given in Table 4 and 5. The moisture pick up of CNO blends packed in FL material during the period of 120 days at 38 °C / 90% RH and 27 °C / 65% RH showed slight or no increase in moisture pickup as to be expected. The colour values of the CNO blends during the storage period of 120 days at 38 °C / 90% RH and 27 °C / 65% RH showed little or no change during the storage. The FFA content of the CNO blends during the storage of 120 days showed little or no change as there was no change in moisture content. The CNO blends stored at 38 °C / 90% RH showed slight increase in peroxide development in the range of

Table 4. Storage behavior of coconut oil blends packed in FL packaging material and storage at 38 C /90% RH.

Parameters	CNO blends/ ratios	Blends stored at 38 °C /90% RH Days of Storage				
		0	30	60	90	120
Moisture (%)*	CNO+SFO(1:4)	0.024±0.003^{a}	0.013±0.003^{b}	0.012±0.003^{b}	0.012±0.004^{b}	0.010±0.001^{b}
	CNO+RBO(1:1)	0.027±0.002^{a}	0.022±0.001^{b}	0.011±0.004^{c}	0.011±0.002^{c}	0.009±0.001^{c}
	CNO+SAFO(4:1)	0.036±0.002^{a}	0.029±0.001^{b}	0.015±0.004^{c}	0.015±0.000^{c}	0.017±0.001^{c}
	CNO+SESO(4:1)	0.039±0.004^{a}	0.025±0.001^{b}	0.014±0.001^{c}	0.014±0.003^{c}	0.021±0.003^{b}
	CNO+GNO(1:1)	0.022±0.002^{a}	0.018±0.001^{ab}	0.010±0.001^{b}	0.010±0.009^{b}	0.037±0.001^{c}
	CNO+PO (1:1)	0.018±0.001^{a}	0.012±0.001^{a}	0.012±0.002^{a}	0.012±0.002^{a}	0.015±0.001^{a}
	CNO+PO (1:4)	0.016±0.002^{a}	0.015±0.001^{a}	0.018±0.008^{a}	0.018±0.001^{a}	0.019±0.001^{a}
Colour (5R+Y)	CNO+SFO(1:4)	3.3±0.000^{a}	3.3±0.000^{a}	3.3±0.000^{a}	3.3±0.000^{a}	3.3±0.000^{a}
	CNO+RBO(1:1)	6.0±0.000^{a}	6.1±0.071^{a}	6.0±0.000^{a}	6.0±0.000^{a}	6.0±0.000^{a}
	CNO+SAFO(4:1)	2.5±0.000^{a}	2.4±0.071^{a}	2.5±0.000^{a}	2.5±0.000^{a}	2.5±0.000^{a}
	CNO+SESO(4:1)	5.5±0.071^{a}	5.5±0.000^{a}	5.5±0.071^{a}	5.5±0.000^{a}	5.5±0.000^{a}
	CNO+GNO(1:1)	7.5±0.141^{a}	7.5±0.000^{a}	7.5±0.000^{a}	7.5±0.000^{a}	7.5±0.071^{a}
	CNO+PO (1:1)	10.5±0.000^{a}	10.5±0.071^{a}	10.5±0.071^{a}	10.5±0.000^{a}	10.5±0.000^{a}
	CNO+PO (1:4)	15.5±0.000^{a}	15.5±0.141^{a}	15.4±0.141^{a}	15.5±0.000^{a}	15.5±0.000^{a}
Free fatty acid (%)**	CNO+SFO(1:4)	0.27±0.007^{a}	0.26±0.007^{a}	0.26±0.007^{a}	0.26±0.007^{a}	0.26±0.007^{a}
	CNO+RBO(1:1)	0.69±0.014^{a}	0.69±0.000^{a}	0.69±0.000^{a}	0.68±0.007^{a}	0.68±0.000^{a}
	CNO+SAFO(4:1)	0.98±0.014^{a}	0.97±0.000^{ab}	0.98±0.000^{abc}	0.99±0.000^{ac}	1.02±0.000^{d}
	CNO+SESO(4:1)	1.26±0.014^{e}	1.25±0.014^{a}	1.29±0.007^{b}	1.30±0.007^{b}	1.31±0.000^{b}
	CNO+GNO(1:1)	1.47±0.014^{g}	1.46±0.014^{a}	1.46±0.014^{a}	1.51±0.007^{b}	1.51±0.000^{b}
	CNO+PO (1:1)	0.75±0.014^{a}	0.75±0.000^{a}	0.75±0.007^{a}	0.78±0.000^{b}	0.78±0.000^{b}
	CNO+PO (1:4)	0.49±0.000^{a}	0.52±0.000^{b}	0.53±0.007^{b}	0.53±0.007^{b}	0.57±0.007^{c}
Peroxide value (meq O_2/Kg oil)***	CNO+SFO(1:4)	1.96±0.007^{a}	4.00±0.007^{b}	4.20±0.269^{c}	4.20±0.007^{d}	6.00±0.092^{e}
	CNO+RBO(1:1)	1.03±0.049^{a}	2.00±0.000^{b}	2.01±0.000^{b}	2.04±0.007^{b}	2.06±0.028^{b}
	CNO+SAFO(4:1)	2.98±0.042^{a}	3.04±0.000^{ab}	3.05±0.007^{ab}	3.51±0.014^{c}	4.01±0.021^{d}
	CNO+SESO(4:1)	1.95±0.035^{a}	2.00±0.007^{ab}	2.08±0.007^{ab}	2.50±0.007^{c}	2.50±0.057^{c}
	CNO+GNO(1:1)	1.80±0.007^{a}	2.00±0.000^{ab}	2.35±0.283^{abc}	2.87±0.042^{cd}	3.04±0.014^{d}
	CNO+PO (1:1)	1.25±0.007^{a}	1.85±0.007^{b}	1.97±0.028^{bc}	1.98±0.014^{bc}	2.24±0.078^{c}
	CNO+PO (1:4)	1.96±0.000^{a}	3.18±0.014^{b}	4.28±0.106^{c}	4.94±0.014^{d}	5.99±0.000^{e}

*Values with different superscript in the row indicates p value is <0.001, considered significant changes in moisture content as compared to initial moisture.

Values in the row with same superscript indicate p value is >0.05, considered that there is no significant changes.

**Values with different superscript in the row indicates p value is <0.001, considered significant changes in free fatty acid content as compared to initial free fatty acids.

***Values with different superscript in the row indicates p value is <0.001, considered significant changes in peroxide as compared to initial peroxide.

Table 5. Storage behavior of coconut oil blends packed in FL packaging material and storage at 27 C /65% RH.

Parameters	CNO blends/ ratios	Blends stored at 27 °C /65% RH Days of Storage 0	60	120
Moisture (%)*	CNO+SFO(1:4)	0.024±0.003^{a}	0.019±0.003^{a}	0.034±0.003^{b}
	CNO+RBO(1:1)	0.027±0.002^{a}	0.017±0.003^{b}	0.013±0.002^{b}
	CNO+SAFO(4:1)	0.036±0.002^{a}	0.025±0.000^{b}	0.030±0.001^{c}
	CNO+SESO(4:1)	0.039±0.004^{a}	0.021±0.001^{b}	0.024±0.002^{b}
	CNO+GNO(1:1)	0.022±0.002^{a}	0.021±0.001^{a}	0.021±0.005^{a}
	CNO+PO (1:1)	0.018±0.001^{a}	0.021±0.004^{ab}	0.014±0.000^{ac}
	CNO+PO (1:4)	0.016±0.002^{a}	0.018±0.000^{a}	0.012±0.001^{b}
Colour (5R+Y)	CNO+SFO(1:4)	3.3±0.000^{a}	3.3±0.000^{a}	3.3±0.000^{a}
	CNO+RBO(1:1)	6.0±0.000^{a}	6.0±0.000^{a}	6.0±0.000^{a}
	CNO+SAFO(4:1)	2.5±0.000^{a}	2.5±0.000^{a}	2.5±0.000^{a}
	CNO+SESO(4:1)	5.5±0.071^{a}	5.5±0.000^{a}	5.5±0.000^{a}
	CNO+GNO(1:1)	7.5±0.141^{a}	7.5±0.000^{a}	7.5±0.000^{a}
	CNO+PO (1:1)	10.5±0.000^{a}	10.5±0.000^{a}	10.5±0.000^{a}
	CNO+PO (1:4)	15.5±0.000^{a}	15.5±0.071^{a}	15.5±0.000^{a}
Free fatty acid (%)**	CNO+SFO(1:4)	0.27±0.007^{a}	0.27±0.007^{a}	0.26±0.000^{a}
	CNO+RBO(1:1)	0.69±0.014^{a}	0.69±0.000^{ab}	0.74±0.014^{ac}
	CNO+SAFO(4:1)	0.98±0.014^{a}	0.98±0.000^{a}	1.02±0.007^{b}
	CNO+SESO(4:1)	1.26±0.014^{a}	1.26±0.014^{a}	1.27±0.014^{a}
	CNO+GNO(1:1)	1.47±0.014^{a}	1.47±0.007^{a}	1.53±0.007^{b}
	CNO+PO (1:1)	0.75±0.014^{a}	0.75±0.000^{a}	0.75±0.000^{a}
	CNO+PO (1:4)	0.49±0.000^{a}	0.49±0.007^{a}	0.52±0.007^{c}
Peroxide value (meq O_2/Kg oil)***	CNO+SFO(1:4)	1.96±0.007^{a}	3.52±0.000^{b}	3.02±0.014^{c}
	CNO+RBO(1:1)	1.03±0.049^{a}	2.00±0.000^{b}	2.02±0.000^{b}
	CNO+SAFO(4:1)	2.98±0.042^{a}	3.52±0.021^{b}	4.00±0.014^{c}
	CNO+SESO(4:1)	1.95±0.035^{a}	2.01±0.000^{b}	2.06±0.035^{b}
	CNO+GNO(1:1)	1.80±0.007^{a}	2.01±0.000^{b}	2.01±0.021^{b}
	CNO+PO (1:1)	1.25±0.007^{a}	2.01±0.000^{b}	2.22±0.247^{b}
	CNO+PO (1:4)	1.96±0.000^{a}	4.01±0.028^{b}	4.33±0.502^{b}

*Values with different superscript in the row indicates p value is <0.001, considered significant changes in moisture content as compared to initial moisture.
Values in the row with same superscript indicate p value is >0.05, considered that there is no significant changes.
**Values with different superscript in the row indicates p value is <0.001, considered significant changes in free fatty acid content as compared to initial free fatty acids.
***Values with different superscript in the row indicates p value is <0.001, considered significant changes in peroxide as compared to initial peroxide.

2.06 meq O_2/ kg of oil for CNO + RBO blend to 6.00 meq O2/ kg of oil for CNO + SFO blend as the entrapped O_2 was utilized.

Conclusion

The results indicated that the stability of CNO blends was influenced by the barrier properties of packaging materials, storage periods, storage conditions and blend composition. The packing material FL which had greater barrier properties provides more than one year shelf life to CNO blends as against 2-'4 months in PA. The CNO blends rich in PUFA and MUFA showed rapid quality deterioration during storage as compared to SFA rich CNO blends. The overall results suggested that the storage stability of the packed coconut oil blends mainly depends on the barrier properties of the packing material against oxygen, light and temperature. Thus, the storage stability of the packed coconut oil blends can be improved by the selection of a suitable packing material and the storage condition.

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RECIPE

PRAWN KHATTA

Ingredients:

Onion	-	one
Prawns	-	one cup
Turmeric Powder	-	half tsp
Coriander powder	-	1 ½ tsp
Chilli powder	-	one tsp
Cumin seeds	-	one tsp'
Fenugreek	-	¼ tsp
Coconut scrapped	-	one cup
Tomatoes	-	4
Tamarind extract	-	one tbsp
Coconut oil	-	3 tbsp
Salt	-	to taste

Method : Roast cumin seeds and fenugreek powder. Grind coconut nicely. Fry chopped onion and prawns well in 3 tbsp of coconut oil. Add powders and fry again. Add coconut, tomatoes and tamarind juice and salt. Cook till done.

CHICKEN KURMA

Ingredients:

Chicken	-	one kg
Green chillies	-	10
Ginger	-	2 inch piece
Cumin seeds	-	1 tsp
Pepper	-	1 tsp
Turmeric	-	½ tsp
Curd	-	½ cup
Cashewnuts	-	10
Garlic	-	6 flakes
Cinnamon	-	2 inch piece
Cloves	-	6
Cardomom	-	4
Onion	-	2
Coriander leaves	-	one bunch
Coconut	-	1
Lime	-	half
Salt	-	to taste

Method: Cut the chicken into big pieces. Grind all the masala. Grind half of the coconut and coriander leaves separately. Grind onions and fry till golden brown. Add masala except the cashew nuts and coconut and fry well till oil comes up. Add the chicken and fry for 5 minutes. Add salt. Extract milk from the remaining coconut and add. Cover and cook till the gravy is thick. Add curd and lime juice and remove from fire.

PUNJABI MASALA CHICKEN

Ingredients:

Chicken	-	one kg
Coconut	-	half cup grated
Curd	-	1 cup
Sesame seeds	-	1 pinch
Minced garlic	-	one tbsp
Onion	-	one
Coriander	-	3 tbsp
Cumin seeds	-	2 tbsp
Cashew nuts	-	20
Tomato chopped	-	1 ½ cup
Turmeric	-	one tsp
Chilli powder	-	2 tsp
Ginger	-	2 inch piece
Cloves	-	5
Oil	-	half cup
Sugar	-	1/4 cup
Salt	-	to taste

Method: Grind the garlic and beat it with curd. Grind ginger, keep aside. Grind coconut and cashew nuts and keep aside. Grind coriander, cumin seeds, chilli powder and half the onions. Cut the chicken into big pieces and slice the nrest of the onions into rounds. Place a vessel over fire and add oil. When it becomes hot, add sugar. When the sugar becomes brown, and boils put the turmeric powder and ginger. Then add the masala of ground coriander, sesame seeds, chilli powder and onions. Fry well by sprinkling curd. When all the oil has disappeared add the tomatoes. Fry for a few minutes. Then add the chicken, ground cashewnuts, salt and coconut. Fry well till oil comes up. Then add 4 cups of water and salt and cook. If a pressure cooker is used, use only 2 cups of water. Remove from the fire when the gravy is thick.

-Indu Narayan