Potentiality of Red Palm Olein in Formulating Novel Functional Salad Dressing

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ABSTRACT

Novel functional salad dressings were formulated by replacing corn oil in conventional salad dressing by red palm olein (RPOL) at 5%, 10%, 15%, 20%, 40%, 60% and 80% levels. Sensory evaluation revealed that salad dressing made from 15% RPOL and 85% corn oil was quite acceptable as the conventional salad dressing (100% corn oil). Therefore, the former two formulas were selected for subsequent evaluation. Salad dressings were stored at room temperature (24°C±2) for 6 months and monitored for their physical properties, fat stability, fatty acid composition and natural antioxidants, namely carotenes, tocopherols and tocotrienols.

The data revealed that the replacement of corn oil in functional salad dressing led to a significant increment in α, γ and δ tocotrienols (29 folds) and carotenes (15 folds) as compared to the control. Storage of salad dressing made from 15% RPOL for 6 months led to significant declines in peroxide and *p*-anisidine values and little declines in saturated and polyunsaturated fatty acids, as compared to the control. Utilization of RPOL as a replacer of corn oil revealed positively significant effects on stability of salad dressing along with maintaining high content of natural antioxidants.

Keywords : ***red palm olein, acceptability, storage stability, fatty acid composition, natural antioxidants.***

INTRODUCTION

In last decades, consumers are becoming more health conscious and are seeking foods with more functional properties that may positively affect their health, prevent nutritional-related diseases and improve physical and mental well-being of the consumers. Such foods that provide health benefits or have a role in disease risk prevention are termed by "functional food". The most commonly accepted definition by several organizations for "functional food" is: "Food or ingredients of food that provide an additional physiological benefit beyond their basic nutrition" (International Life Science Institute, 1999, International Food Information Council, 2006, Day *et al*., 2009).

Today, functional foods are receiving substantial segments of the world food industry. The market for functional foods and bioactive ingredients has experienced growth in the recent years. The global functional food market in 2005 is estimated at around 74 billion US $ and the leading markets are USA, Europe and Japan (Anonymous, 2006, Sirō *et al*., 2008, Granato *et al*., 2010, Sloan, 2010).

However, a food can be made functional by applying any technological or biotechnological means to increase the concentration of, add, remove or modify a particular component as well as to improve its bioavailability to have functional effects (Roberfroid, 1999, Niva, 2007). On the other hand, to design and develop functional foods, it should take into consideration the product properties, i.e., colour, texture, taste and mouth feel as well as stability, safety and bioavailability of micronutrients. However, still the appearance and sensory properties of food are the most important to consumer (Parada & Aguiler, 2007, Day *et al*., 2009).

Red palm olein (RPOL) is considered as a functional oil because it contains about 500 mg/kg carotenoids, mainly, α- and β-carotenes and 800 mg/kg of vitamin E, i.e., tocopherols and tocotrienols (Rossi *et al*., 2001, Mortenson, 2005). It is worth to mention that the bioavailability of β-carotene in red palm olein is about 90% (Sundram, 2005). β-carotene, as provitamin A is associated with normal growth, immune function and vision. The current global problem is the risk of children blinding due to the lack of vitamin A (Hekmat & Haines 2003, Sundram, 2005). Moreover, Benade (2001) found that incorporation of red palm olein in diet was effective in reducing vitamin A deficiency in schoolchildren.

Vitamin E isomers are present in RPOL include tocopherols (30%) and tocotrienols (70%). The latter, have been shown to possess potent antioxidant (Serbinova *et al*., 1991, Manim *et al*., 2008), anti-inflammatory (Wu *et al*., 2008), anticancer (Goh *et al*., 1994, Wu *et al*., 2007), neuroprotection (Osakada *et al*., 2004) and cholesterol lowering activities (Minhajuddin *et al*., 2005). Furthermore, vitamin E family are antioxidants that can contribute to the stability of RPOL and other oil based products (Esterhuyse *et al*., 2004, Tan *et al*., 2007). However, RPOL has been used to elevate provitamin A and vitamin E contents in human diets, i.e., cakes, biscuit, bread, cookies, rusks, chocolate spread (Stuijvenberg & Benade, 2000, Al-Hooti *et al*., 2002, Al-Saqer *et al*., 2004, Butt *et al*., 2006, El-Hadad *et al*., 2010, 2011).

The objective of the present study was to formulate an acceptable and novel salad dressing using red palm olein. Moreover, the salad dressings were stored for 6 months at room temperature, and the changes in physical properties and storage stability indices were monitored.

MATERIALS AND METHODS

Materials

Red palm olein (RPOL) was kindly secured by Caroteino SDN BHD Company, Malaysia. Other ingredients were purchased from local supermarket, Alexandria, Egypt.

Methods

Technological Methods

Figure (1) illustrates the processing steps applied in the present study to manufacture salad dressing after a set of preliminary experiments. Corn oil was replaced by RPOL at 5%, 10%, 15%, 20%, 40%, 60% and 80% levels.

Sensory Evaluation

Salad dressings were evaluated by 10 trained panelists (4= males and 6 = females, 30 to 37 years age) from staff members of the Food Science and Technology Department, Faculty of Agriculture, Alexandria University, Alexandria, Egypt. The panelists were asked to judge the samples on 9-point hedonic scale, 1= Extremely dislike, "poor" to 9= Extremely like, "excellent" (Kramer & Twigg 1973, Waite *et al*., 2009) for colour, flavour, texture, taste and overall acceptability. All salad dressing samples were coded with 3-digit random number and presented to the panelists in white plastic cups individually. Order of servings were completely randomized. Water and bread were provided for cleaning palate between samples (Anonymous, 1981, Worrasinchai *et al*., 2006).

Physical Tests

The viscosity was measured at 25°C using Brook Field Viscometer, Model LV-II (Brook Field Engineering Laoratories Company, Stoughoto, Ma,

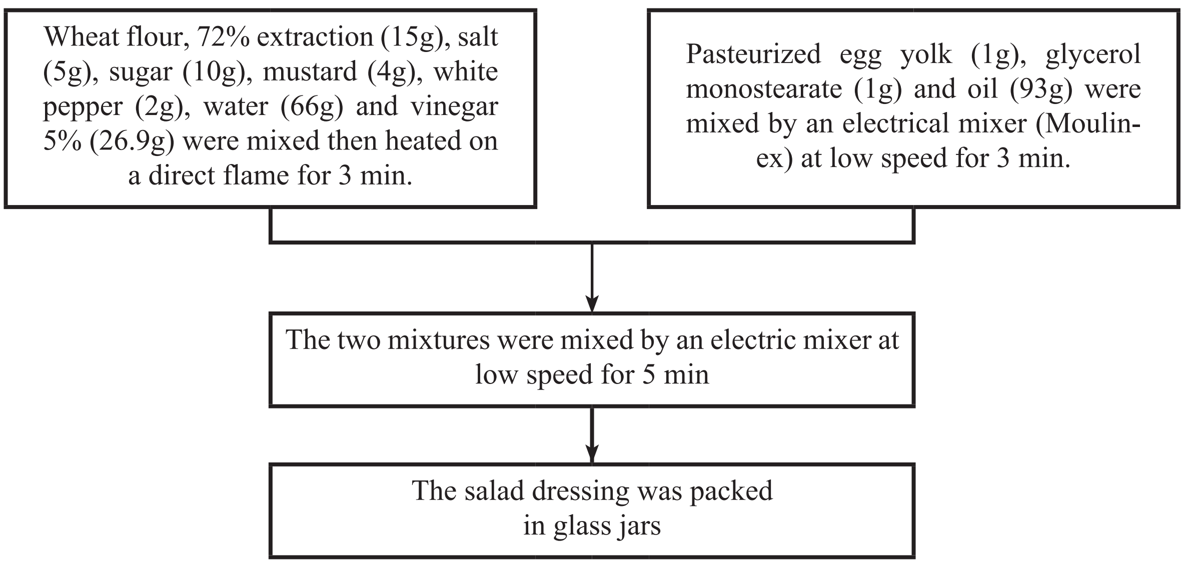

Fig. 1: Flowchart of processing salad dressing

USA) spindle number 3 at speed 4 rpm (Acton & Saffle 1971). The emulsion stability was determined according to Hung & Zayas (1991).

Chemical Analysis

Oil of salad dressing was separated by the freez-thaw method (Warner *et al*., 1986). The separated oil was collected and dried over anhydrous sodium sulfate.

The peroxide value, free fatty acids and acid value were determined according to the AOAC (2000). *p*-Anisidine value was determined according to the IUPAC (1979).

Fatty Acid Analysis by GC

Fatty acid methyl esters (FAMEs) were prepared using the BF_3 method (AOCS, 2001). The fatty acid composition was analysed in FAMEs using a HP Hewlett Packard 6890 GC, equipped with a Supleco SP™-2340 (USA) fused silica capillary column (60m length, 0.25mm diameter and 0.2 µm thickness), the initial flow was 0.8 ml/min, the pressure 23.61 psi, the average velocity 20 m/s, and the run time 50 min. The oven temperature was initially 150°C and was ramped to 210°C after 30 min. The auto injection (HP Hewlett 6890) and flame ionization detector temperature was 240°C. The split flow ratio of the helium carrier gas was 83.3 ml/min. The saver flow was 20m/min. and the pressure 23.61 psi. The injection volume of the sample was 1µl. Identification of FAMEs was based on the comparison of their retention times with those of FAMEs standards mixture (Supelco FAME Mix RM-6, Supleco 07631-1 AMP). Quantification was performed by the computer control using the area normalization (AOCS, 2001).

Tocopherols and Tocotrienols Analysis by HPLC

A 0.1g of sample was weighed and transferred into a 10 ml volumetric flask, and was made up to volume with n-hexane. The solution was filtered and 20 µl were injected into a column (Jones Chromatography UK, Genesis silica 25 cm length x 4.6 mm inside diameter x 4.6 inch outside diameter, 30°C) using a Waters 2695 separation Module HPLC (Waters corporation, USA), equipped with an auto injector (Aglient Techno Logist G 1321A, DE, 14903748, UK). The mobile phase consisted of a mixture of hexane: iso-propanol (99.5:05, v/v), this was set at a flow rate of 1.4 ml/min, and the run time was set for 22 min. Pure tocopherols (Sigma, St. Louis, Mo, USA) and tocotrienols (95.4%) developed by MPOB, Malaysia, were used as standard references (these tocotrienols were extracted from palm oil and were traceable to Merck individuals α, β, γ and δ tocotrienols). The standard solutions were prepared by taking 0.1 ml) from each standard into a 10 ml volumetric flask, and was made to volume with n-hexane, to get 100 ppm. The content of tocopherols and tocotrienols were expressed as wt. % of the total weight of the sample. Quantification was performed by computer control using the area normalization (AOCS, 2001).

Total Carotenes Determination

Total carotenes were determined by spectrophotometry at 440 nm using IE-UV visible, varian No. 94 071244, UK, as described by the AOAC (2000). Total carotenes as β-carotenes, were calculated using Gary Windows UV software No. 8510162500.

Statistical Analysis

Data in triplicates were subjected to analysis of variance (ANOVA) and Duncan's multiple range test to separate the treatment means (Steel & Torrie 1980). The analysis was computed using the SAS program.

RESULTS AND DISCUSSIONS

Sensory Properties

The data presented in Table (1) reveal that the quality attributes of salad dressing made from up to 80% RPOL as a replacer of corn oil, varied significantly in acceptability. As the percentage of RPOL increased, the salad dressing received mean score values in all judged quality by panelists statistically lower than those of the control one. Such results can be explained on the basis that the deep orange-red colour of RPOL, which is not familiar to the public, may negatively affect the sensory attributes of salad dressings as judged by panelists. However, the present data are in accordance with those reported by Hekmet & Haines (2003) and El-Hadad *et al*. (2010, 2011).

The data given in Table (1) show that the salad dressing made from 15% RPOL+ 85% corn oil was significantly quite acceptable as the control (100% corn oil). Meanwhile, all the salad dressing samples made from RPOL (5%, 10% and 15%) were signifcanly comparable in terms of overall acceptability as judged by the panelists. Thereby, the superior

Table 1: Sensory evaluation of salad dressing samples made from 100% corn oil and by substituting with RPOL at different levels

Samples		Organoleptic properties (out of 10 marks)				
		Colour	Flavour	Taste	Texture	Overall acceptability
Control*		6.00^{a}	6.25^{a}	5.80^{b}	6.50^{a}	6.10^{a}
Substitution with Red Palm Olein	5%	4.30^{c}	5.80^{a}	5.80^{b}	6.50^{a}	5.60^{ab}
	10%	5.00^{b}	6.00^{a}	6.60^{a}	6.50^{a}	6.00^{ab}
	15%	5.30^{b}	6.00^{a}	6.40^{ab}	6.50^{a}	6.05^{a}
	20%	4.90^{bc}	5.20^{b}	5.40^{b}	6.20^{ab}	5.42^{b}
	40%	4.40^{c}	5.00^{bc}	4.70^{c}	5.50^{b}	4.90^{bc}
	60%	3.90^{c}	4.70^{c}	4.20^{c}	5.00^{b}	4.45^{c}
	80%	3.00^{d}	4.00^{d}	3.40^{d}	2.50^{c}	3.22^{d}

RPOL: Red Palm Olein. * Control: 100% corn oil.
Means in a column not sharing the same subscript are significantly different at $P \leq 0.05$.

salad dressing sample which preferred by the panelists was that containing 15% RPOL. Accordingly, the salad dressing made from 15% RPOL+ 85% corn oil was formulated and selected along with the control for subsequent investigation.

Storage Stability Study

Conventional (control) and formulated functional salad dressing were stored at room temperature (24°C±2) for 6 months. Physical properties, fat stability indices, fatty acid composition, and natural antioxidants were monitored at 0, 3 and 6 months.

Physical Properties

Table (2) shows that the viscosity of the salad dressing made from 15% RPOL+ 85% corn oil varied significantly being lower than that of the control at zero time and also after storage for 3 and 6 months. It was noticed that, the viscosity decreased gradually and significantly for both salad dressing samples as a result of elongating the storage period.

The emulsion stability was found to be 1 for both salad dressings. Storage of these products at room temperature for 6 months did not significantly affect the emulsion stability, as shown in Table (2). Granger *et al*. (2005) investigated the interface characteristics and rheological properties of oil in water emulsions as affected by different types of oils and found that the stability of the emulsions was attributed to less unsaturated oil in interfacial interactions among the oil phase, fatty acids emulsions and the adsorbed protein.

Fat Stability

Table (3) shows that, peroxide values (PV) of both formulas were equal at zero time and were mostly comparable after 3 months of storage. On the other hand, *p*-anisidine value (*p*-AV) as well as free fatty acids (FFA) and acid value (AV) were 2.8, 0.37%, 0.89 and 1.9, 0.35%, 0.76 for control and RPOL, respectively at zero time. These values increased significantly in both formulas as the storage period was elongated to 6 months.

The data presented in Table (3) indicate that replacement of 15% corn oil by RPOL, in formulating salad dressings did not significantly change the acid value or free fatty acids percentage as compared to the control salad made from 100% corn oil, while this replacement led to significantly lesser increasing in each of peroxide and *p*-anisidine values than in the control one. In accordance, Karas *et al*. (2002) found that the storage temperature, storage time and type of mayonnaise influence significantly the stability, homogeneity, mouthfeel, acidity, odour, flavour rancidity, pH, acid and peroxide values.

Fatty Acid Composition

Table (4) shows that linoleic acid ($C_{18:2}$) was the most abundant fatty acid in salad dressings at zero time, ranged from 48.3% to 54.3%, followed by oleic acid ($C_{18:1}$), which ranged from 29.9% to 31.8%. Palmitic acid ($C_{16:0}$) comprised the third most abundant fatty acid in salad dressings being in a range of 11.5%–15.5%. Meanwhile, myristic, margaric and stearic acids exhibited values around

Table 2: Physical properties of salad dressings during storage for 6 months at room temperature

Physical properties	Storage period					
	Zero time		3 months		6 months	
	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil
Viscosity (P)	8.8±1.1^{ax}	5.5±1.8^{bx}	8.1±1.3^{ay}	4.9±1.6^{by}	7.2±1.2^{az}	4.3±1.6^{bz}
Emulsion stability	1.0±0.0^{ax}	1.0±0.0^{ax}	1.0±0.1^{ax}	1.0±0.1^{ax}	1.0±0.2^{ax}	1.0±0.3^{ax}

RPOL: Red Palm Olein. Each value is expressed as means±SD. of three determinations.

Means in a row not sharing the same letter (a and b) at the same storage period and means not sharing the same letter (x, y and z) at different storage period are not significantly different at P≤ 0.05.

Table 3: Stability indices of salad dressings during storage for 6 months at room temperature

Parameters	Storage period					
	Zero time		3 months		6 months	
	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil
Peroxide value (meq peroxide/kg)	2.30±0.35^{az}	2.30±0.48^{az}	6.50±0.24^{ay}	6.00±0.27^{by}	9.80±0.28^{ax}	8.70±0.82^{bx}
p–anisidine	2.80±0.05^{az}	1.90±0.11^{by}	3.20±0.07^{ay}	1.50±0.08^{by}	5.10±0.04^{ax}	2.70±0.04^{bx}
Acid value	0.89±0.11^{ay}	0.76±0.09^{az}	0.98±0.31^{axy}	0.95±0.29^{ay}	1.98±0.46^{ax}	1.58±0.17^{ax}
FFA (%)	0.37±0.04^{ay}	0.35±0.04^{az}	0.45±0.19^{axy}	0.43±0.17^{zy}	0.90±0.28^{ax}	0.72±0.09^{ax}

RPOL: Red Palm Olein. Each value is expressed as means±SD. of three determinations.

Means in a row not sharing the same letter (a and b) at the same storage period and means not sharing the same letter (x, y and z) at different storage period are not significantly different at P≤ 0.05.

Table 4: Fatty acid composition of salad dressings during storage for 6 months at room temperatue

Fatty acids	Storage period: Zero time		3 months		6 months	
	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil
Myristic ($C_{14:0}$)	0.04	0.18	---	0.18	0.05	0.17
Palmitic ($C_{16:0}$)	11.5	15.47	11.64	15.39	11.30	15.07
Margaric ($C_{17:0}$)	0.07	0.08	0.07	0.08	0.07	0.08
Stearic ($C_{18:0}$)	1.03	2.29	1.95	2.31	2.07	2.24
Arachidic ($C_{20:0}$)	0.42	0.41	0.42	0.41	0.40	0.40
TSFA	13.06^{bx}	18.43^{ax}	14.08^{ax}	18.37^{ax}	13.89^{by}	17.96^{ay}
Palmitoleic ($C_{16:0}$)	0.24	0.24	0.23	0.21	0.22	0.24
Oleic ($C_{18:1}$)	29.86	31.78	29.81	31.85	29.62	31.82
TMUFA	30.10^{bx}	32.02^{ax}	30.04^{bx}	32.06^{ax}	29.84^{by}	32.06^{ax}
Linoleic ($C_{18:2}$)	54.43	48.43	54.20	48.03	54.05	47.96
Linolenic ($C_{18:3}$)	0.84	0.79	0.83	0.78	0.82	0.79
TPUFA	55.27^{ex}	49.22^{bx}	55.03^{ax}	48.81^{by}	54.87^{ay}	48.75^{by}
Others	1.06	0.80	1.01	0.77	0.02	0.75

RPOL: Red Palm Olein. TSFA : Total Saturated Fatty Acids.
TMUFA: Total Monounsaturated Fatty Acids. TPUFA: Total Polyunsaturated Fatty Acids.
Means in a row not sharing the same letter (a and b) at the same storage period and means not sharing the same letter (x and y) at different storage period are not significantly different at P≤ 0.05.

Table 5: Tocopherol, tocotrienols and carotenes of salad dressings during storage for 6 months at room temperature

Antioxidants (ppm)	Storage period: Zero time		3 months		6 months	
	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil	100% corn oil	15% RPOL+ 85% corn oil
α–Tocopherol	74.4	94.0	71.0	97.7	67.0	84.5
α–Tocotrienol	5.1	32.6	4.7	32.4	4.5	29.0
β–Tocotrienol	450.0	440.0	430.3	429.6	422.8	416.0
γ–Tocotrienol	6.0	45.0	5.6	43.7	5.3	41.2
δ–Tocotrienol	0.0	15.0	0.0	15.3	0.0	16.0
Total α–tocopherol+ tocotrienols	536.0^{bx}	627.0^{ax}	512.0^{by}	619.0^{ay}	500.0^{bz}	587.0^{az}
Carotenes	5.0^{bx}	77.0^{ax}	4.0^{bx}	75.0^{ay}	4.0^{bx}	75.0^{ay}

RPOL: Red Palm Olein.
Means in a row not sharing the same latter (a and b) at the same storage period and means not sharing the same letter (x, y and z) at different storage period are not significantly different at P≤ 0.05.

1.14% and 2.6% for the control and the salad dressing made from 15% RPOL, respectively.

Replacement of corn oil with 15% RPOL elevated significantly the saturated fatty acids as well as monounsaturated fatty acids on contrary to polyunsaturated fatty acids. Elongation of storage period at room temperature for salad dressing containing 15% RPOL+ 85% corn oil, maintained its content of monounsaturated fatty acids, while it led to a little decline in the saturated and polyunsaturated fatty acids as shown in Table (4).

Natural Antioxidants Composition

Antioxidant composition of the salad dressing samples revealed obvious increment in α-tocotrienol in the salad dressing made from 15% RPOL as compared to the control. The same was true regarding γ-tocopherol being 45 mg/kg versus 6mg/kg, respectively as shown in Table (5).

As it is expected, replacement of corn oil with 15% RPOL in formulating salad dressing resulted in significant elevation in total α-tocopherol and tocotrienols and carotenes contents at zero time as well as after storage for 3 and 6 months at room temperature.

The point of interest is that salad dressing made from 15% RPOL exhibited more than 15 folds of carotenes, around 7 folds of both α-tocotrienol and γ-tocotrienols and 15 folds of δ-tocotrienol than in the control.

The Data presented in Table (5) indicate that storage of the salad dressing samples at room temperature for 6 months led to a significantly gardual decline in antioxidants content as the storage period was extended.

CONCLUSIONS

An acceptable and high quality functional salad dressing could be successfully formulated by partially replacing of corn oil with RPOL at 15% level. The formulated salad dressing had 29 times more α-, γ- and δ-tocotrienols and 15 times more carotenes than the control (100% corn oil).

Production of a such salad dressing, which is used mainly as spread in sandwiches worldwide, can be considered as one of the most effective and sustainable ways of overcoming vitamin A deficiency, which is prevailing in developing countries. Moreover, this salad dressing contains high concentrations of bioactive phytochemicals that have been proved to have health benefits, as it has extensively reported in literature.

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إمكانية استخدام زيت الأوليين الأحمر في توليف صلصة مشهية وظيفية

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تم توليف صلصة مشهية وظيفية وذلك عن طريق إحلال ٥، ١٠، ١٥، ٢٠، ٤٠، ٦٠، ٨٠٪ من زيت النخيل الأحمر بدلاً من زيت الذرة. تبين من نتائج التقويم الحسي للخلطات التي تم توليفها أن الخلطة التي احتوت على ١٥٪ زيت نخيل أحمر، ٨٥٪ زيت ذرة كانت متماثلة تماماً من حيث التقبل مع عينة المقارنة (المصنعة من ١٠٠٪ زيت ذرة)، ومن ثم فقد استخدمت هذه الخلطة في الدراسة التفصيلية اللاحقة وقورنت مع عينة المقارنة. كذلك فقد تم تخزين هذه الخلطة مع عينة المقارنة على درجة حرارة الغرفة (٢٤°م±٢) لمدة ستة شهور مع تتبع الصفات الطبيعية، ثبات الدهن، تركيب الأحماض الدهنية، محتوى مضادات الأكسدة الطبيعية من كاروتينات، توكوفيرولات، توكو ثلاثي إينولات.

تبين من نتائج هذه الدراسة أن خلطة الصلصة تحت الدراسة تحتوي على ٢٩ مرة قدر ما تحتويه عينة المقارنة من ألفا، جاما، دلتا توكو ثلاثي إينولات، كما أنها تحتوي على ١٥ مرة قدر ما تحتويه عينة المقارنة من الكاروتينات. وأدى تخزين هذه الخلطة لمدة ستة شهور على درجة حرارة الغرفة إلى حدوث نقص معنوي في كل من رقم البيروكسيد، قيمة البارا أنسيدين، محتوي الأحماض الدهنية المشبعة وعديدة عدم التشبع وذلك مقارنة بعينة المقارنة.

على ضوء هذه النتائج فإنه يمكن إنتاج صلصة مشهية وظيفية عن طريق إحلال ١٥٪ من زيت الذرة بواسطة زيت النخيل الأحمر، وهذه الصلصة تتميز بثباتها التخزيني إلى جانب احتوائها على مضادات الأكسدة الطبيعية بتركيزات عالية.