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Optimization of Fatty Acid Composition by of Cooking Oils Blending of Different Plant Oils

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Authors' contributions

This work was carried out in collaboration among all authors. Author RSF designed the study, wrote the protocol, supervised the research work and wrote the first draft of the manuscript. Author MAM managed the analyses of the study, managed the literature searches and performed the statistical analysis. Authors HAH and AN supervised the study and reviewed the work. All authors read and approved the final manuscript.

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ABSTRACT

Fats and oils are important carriers and protectors of liposoluble vitamins: A,D,E,K; Provitamins like carotenes & tocopherols and liposoluble nutraceutical products: Squalene, polyphenols, sterols etc. However, most of single oils do not have the correct balance to meet humans' nutrition requirement. Some of the most well-known non healthier attributes of using single oils for cooking and other edible purpose are presence of an non balanced amount of Omega 6 (W6) or non-balanced amounts of saturated fatty acids (SFA) or Low content of omega 3 (W3), Excessive PUFA that affects the oil stability during drastic heat treatment in frying applications which yields an harmful oxidations products in oil. Also the UnbalancedW6/W3 content in cooking oil or foods containing fats and Unbalanced short-chain and long-chain FA etc. Unbalanced oil consumption regarding the omega 6: omega 3 ratio affects the health in many aspects as is proven by the scientific findings. Excessive omega 6 fatty acid in human diet promotes inflammation, reduce immunity, increases risk

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of heart diseases, risk of diabetes, allergy symptoms, hypertension risk, cancer risk, osteoporosis, depression risk and weaken memory.
In this study, different oils composites of vegetable oils were formulated from tropical oils and seed oils including palm oil fractions, Canola oil, corn, soybean oil, Sunflower seed oil, Olive oil, sesame oil, rice bran oils, cotton seed oil and MCT rich oils . The selected oils are differing in their content of SFA, MUFA and PUFA fatty acids and in their n–3, n–6 and n–9 ratios. The fulfillment of smart balance requirements of FAO/WHO recommended that, approximately 30% of total energy intake (daily) should come from oils and fats. From that total, around 1/3 should be saturated, 1/3 monounsaturated and 1/3 polyunsaturated. It is important that the balance ofW6/W3 be near 2-5/1 has been targeted in these healthier cooking oils composites. Physio-chemical characterization of the blends during thermal treatment applications like frying has been studied. Results showed marked differences in the FAs composition balance between the different oils used for preparing the oil composites. The prepared blends achieve the optimum omega 6: omega 3 balances to prevent control the inflammations had n–6 to n– 3 FAs ratio which varied from 4.9:1 to 4.5:1. This review will help the edible oil producers and related food industry to find out the most economically viable oil blends for cooking purposes, with maximum nutrition as well as desirable physicochemical properties.

Keywords: Oil blending; healthier impact; oxidative stability; sensory attributes; cooking and frying applications.

1. INTRODUCTION

Cooking Oil Is an edible oil that is liquid and clear at room temperature, 75°F or 23.9°C, that may be used for cooking. Cooking oils are typically used for vegetables cooking, Pan or shallow frying, deep-fat frying, sauces, gravies, marinates, and other non-refrigerated food preparations where a clear liquid oil has application. Cooking oils usually congeal or solidify at refrigerator temperatures. Ideal cooking and frying oils need to be more stable to oxidation than salad oil because of the higher temperatures to which cooking oils are exposed. Temperature stability is especially required in fats and oils used in shallow or deep-fat frying. The frying cycle causes an increase in the polarity of the water/oil system due to the reactivity of the oil used, with a negative effect on the physicochemical and rheological characteristics of the product, combined with potential undesirable biological effects in the metabolic phase, such as the decrease of the nutritional value of the product and possible interference with endogenous enzyme activity during digestion and transport.

The above discussion demonstrates the need to provide oil compounds for frying and cooking which have high stability under thermal stress, with less development of degradation products during frying and/or cooking and less absorption of these degradation products on the surface of the food.

On other side salad oils must be physically stable so that they do not crystalize at refrigerated temperatures. In this paper, a set of oil blends have been studied and several cooking / frying trials have been conducted which enabled to identify some optimum blends for the preparation of vegetable oil mixtures in order to obtain edible oil compositions, particularly for frying and cooking food, which meet the aforementioned requirements. .

There are some basic criteria have been identified by inventors for the preparation of vegetable oil mixtures in order to obtain edible oil compositions, particularly suitable for frying and cooking food [1].

Therefore, the inventor relates between the edible oil composition, and the particular use in frying and cooking foods applications. The said composition consisting of a mixture of vegetable oils characterized by a ratio by weight of (MUFA) to (PUFA) in the range from 5 to 8, and preferably from 6 to 7 and a percentage of saturated fatty acids (SFA) in the range from 18% to 22%, preferably 19% to 21%, and content of antioxidant substances in the range from 50 to 500 ppm, preferably 200 to 300 ppm.

Oil Compositions having the characteristics specified above can be produced by mixing different vegetable oils, taking into account the known content of saturated and unsaturated (mono and polyunsaturated) fatty acids of each oil in the mixture.

In this study a various oil blend composition of the mixture, has been studied while remaining within the ranges stated above in relation to the values of (MUFA:PUFA) and considerable amount of (SFA).

It was an advantageous aspect of the study, since it permits a degree of flexibility of production in respect of cost, availability and planning.

Another main advantage of the blending process that there is no any change of oil nature by any conversion process as hydrogenation or inter-esterification, so they obtained oil blends that fit the purpose of the study are claimed as hundred percent nature. The antioxidant used is not limited to synthetic types but also the natural antioxidants were selected to fulfill the claim of clean label and 100% natural product. Also, it does not need any capital investments for manufacturers to produce the optimum healthy cooking oils as there are no capital investments in conversion units to change the nature of oil by fractionation or interesterification.

Blending is defined as mixing of two or more ingredients to achieve the pre-set objectives. In blending, composite ingredients share advantages and disadvantages according to the blend ratio. When it comes to edible oils, blending can modify the physicochemical properties of oils without changing their chemical composition. Therefore, oils can be blended to derive the protective advantage due to the presence of specific ingredients that offer protection against oxidation to improve frying recyclability. Furthermore, Blending oils make it possible to get an ideal mix with the best of each raw material in terms of heath impact. Vegetable oils blend results in excellent color, natural taste and neutral flavor. It is ideal for frying and other industrial applications [2,3].

2. OIL BLENDS OF HEALTHIER IMPACT (SMART BALANCE FORMULAS)

WHO and FAO [4] standardized limitations regarding the healthier total fat intake and the fatty acid composition for the healthier fat formulas.

The limitations regarding fat composition start with total fat intake. For adults 20-35% of total energy should be provided by fat and oil. It considers the mean percentage (30%E) as the basis for calculation the fatty acid limitations.
SFA: The optimum range is less that 10%E or less than 33% of total fat.

Considering the healthier impact of individual saturated fatty acids composition, the lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids increase LDL cholesterol whereas stearic (C18:0) has no effect.

Replacing SFA (C14:0 and C16:0) by PUFA reduce LDL and Total HDL concentration but replacing by MUFA have lesser effect. Replacing SFA with PUFA decreases the risk of CHD. There is a possible positive relationship between SFA intake and increased risk of diabetes.

a. n-6 PUFA: the optimum range is 8.3-9 %E (energy percentage) or 8.3-30% of total fat.
b. n-3 PUFA: the optimum range is 0.5-2%E or 1.7-6.6% of total fat.
c. PUFA: the optimum range is 6-11%E or 20-36% of total fat.
d. SFA: the optimum range is less that 10%E or less than 33% of total fat.
e. MUFA: there is no limitation for MUFA and determined by difference i.e.

MUFA = Total fat intake (%E) – SFA (E%) – PUFA (E%) – TFA (%E).- Replacing Carbohydrates with MUFA increases HDL cholesterol concentrations.

The lower value or AI (2.5–3.5%E) corresponds to the prevention of deficiency symptoms, whereas the higher value as part of a healthy diet contributing to long term health by lowering LDL and total cholesterol levels and therefore the risk for CHD.

A number of studies have been conducted before on different oil blends. The target of those studies was either to reach a formula of higher oxidative stability during cooking and frying, or to reach a formula with healthier impact. Some of those blends have already reached the market as edible products. However, few studies are done to correlate between the better cooking and frying stability and healthier impact at the same time [2]. In this review, number of formulas that have been addressed and studied that can be used for either healthy purposes, or better oxidative stability. This review can help the oil producing industry to find out the most economically viable oil blends for cooking purposes, with maximum nutrition as well as desirable physicochemical properties.

According to the nutritional guidelines, such as AHA / WHO guideline, vegetable oil blends that can satisfy a ratio of 1:1:1 between SAFA, MUFA & PUFA is considered the optimum smart blends regarding to health impact. Blend of palm olein &SBO (50:50) and that of palm olein: sesame oil (52:48) can satisfy the requirement of the optimum smart blend of SAFA:MUFA:PUFA ratio 1:1:1 [5].

In this study, the different sources of vegetable oils including but not limited to Soybean, Sunflower, Canola, Olive, Corn and palm fractions, etc. are utilized to make proposed combinations as listed in Tables 1 & 2. Table 1 shows the formulas with no olive while Table 2 shows the formulas containing olive oil in the blend. The selected formulas were derived by minimizing the SFA and replace it by PUFA. This is because of the studies done which indicates that replacing SFA (C14:0 and C16:0) by PUFA reduce LDL and Total/HDL concentration. Also replacing SFA with PUFA decreases the risk of CHD (Coronary Heart Disease). However, replacing by MUFA has lesser effect [3].

Table 1. Proposed smart formulas without olive oil

No.	Oil Blend	Content	SFA ≤ 33%	MUFA	PUFA 20-36%	N-3 PUFA 1.7-6.6%	N-6 PUFA 8.3-30%
	Mean Range		16.5%		28%	4.15%	19.15%
1-	DF	20%	13.20	54.7	25.70	6.00	19.70
	Canola	80%					
2-	Corn	20%	8.20	51.60	32.00	6.20	25.80
	Canola	80%					
3-	Canola	80%	7.70	51.60	34.10	6.10	28.00
	Sunflower	20%					
4-	DF	10%	10.45	53.15	29.90	6.05	23.85
	Canola	80%					
	Sunflower	10%					
5-	Corn	10%	10.70	53.15	28.85	6.10	22.85
	DF	10%					
	Canola	80%					

Table 2. Proposed smart formulas with olive oil

No.	Oil blend	Ratio	SFA ≤ 33%	MUFA	PUFA 20-36%	N-3 PUFA 1.7-6.6%	N-6 PUFA 8.3-30%
Mean Range			16.5%		28%	4.15%	19.15%
1	Olive	50%	11.00	66.00	32.65	4.15	14.50
	Canola	50%					
2	Soya	40%	15.00	54.20	28.68	2.68	26.00
	Olive	60%					
3	Canola	10%	8,15	56.10	29.33	6.13	23.20
	Sunflower	80%					
	Olive	10%					
4	Sunflower	10%	14.55	54.90	29.20	2.18	26.30
	Soya	30%					
	Olive	60%					
5	Corn	10%	8.40	56.10	28.28	6.18	22.10
	Olive	10%					
	Canola	80%					
6	Canola	40%	11.80	62. 60	32.85	3.95	17.70
	Soya	10%					
	Olive	50%					

3. OIL BLENDS WITH HIGHER STABILITY DURING FRYING

Oils and fats intended for commercial frying applications must be stabilized to prevent deterioration caused by oxidation, polymerization, and hydrolysis during high-temperature use. Modifying the fatty acid composition of the oil—the most common method to stabilize frying oils can be done by several methods. For example, blending polyunsaturated oils with more saturated or monounsaturated oils is an option to adjust fatty acid levels to optimal levels, such as combining high-oleic sunflower oil with corn oil or hydrogenated soybean oil with soybean oil [6–8]. Chemically altering the existing fatty acid ratios by hydrogenation increases saturated fatty acids and decreases polyunsaturated fatty acids to produce more stable oil [8-9].

The suitability of oils for cooking purpose depends on the extent to resist oxidation under harsh conditions of frying regarding exposure to heating and aerobic conditions.

The oxidized fats in a very high dosage have been shown to have toxic effects. Therefore, studies in which degradation of frying oils is measured and analysis of rancidity volatiles are valuable in understanding the oil oxidation state. Although quality of pure vegetable oils before and after frying has been evaluated by many researchers but the physicochemical properties for binary oil blends have not been studied extensively. Some of this studies are summarized in the following section based on the type of vegetable oil used [10-12].

Table 3 shows the oxidative stability of some heat stable oil blends conaining the oils which are by nature having natural antioxnatns as Rice bran which is naturally rich by gamma oryzanol which is polyphenol rich in physically refined rice bran oil to more than12000 ppm and this amount is reduced drastically in chemically refined rice bran to less than 5000 ppm .

Second naturally heart stable studied in this blend is the Sesame oil which is well known for its oxidative stability; one of the reasons for this extra-stability is attributed to its tocopherol content. Sesame oil is highly resistant to oxidative deterioration as compared with other edible vegetable oils. The superior oxidative stability is not only attributed to the presence of tocopherols, but it is mainly associated with the unique group of compounds-lignans. The two major lignans which are responsible for superior heat stability of sesame oil are found in raw sesame seeds are called sesamin and sesamolin.. Sesamin has been found in other plants, whereas sesamolin is characteristic of sesame and has not been found in plants other than Sesamum.

The other two naturally heat stable oils included in the study are cotton seed oil and palm olein. vegetable oil blends based on sesame

Sesame oil contains 45-49% monounsaturated fatty acids and 37% to 41% polyunsaturated fatty acids which are more prone to auto-oxidation and hydrolytic reaction during frying. However, the presence of the thermally stable lignans in the oil offers protection against oxidation [5].

3.1 Sesame-Rice Bran and Sesame-Cotton Seed Blends

A number of studies have been done on the effect of adding sesame oil on different vegetable oils. The effect of adding sesame oil on cotton seed, rice bran and palm olein in terms of stability during frying, has been studied. In this study, two main ratios of Sesame oil: other vegetable oils were used (20:80 and 80:20). The oil blends were used for frying ready to eat (RTE) snacks. The oil was extracted from the products via Soxhlet apparatus. The extracted oil was then analyzed for various rancidity parameters, such as peroxide value, free fatty acid and anisidine value. It was observed that the addition of sesame oil improved the stability of cotton seed oil and rice bran oil, in terms of their peroxide value. It was also observed that sesame: rice bran and sesame: cotton seed showed the best oxidative stability in terms of all the analysis tests. Sesame with palm olein showed a good stability at higher ratio of palm olein as well.

Table 3 oil blends after frying shows the impact of shallow frying at 180°C on common oxidation stability criteria which are PV, p-A.V. and FFA after 5 domestic frying cycles.

According to the WHO and FAO standards for healthier formulas, the formula of sesame: rice bran (20:80) can be classified as smart formula (see Table 4) Also, it shows better stability during frying, thus it can be considered as a promising stable frying and cooking medium.

3.2 Vegetable Oil Blends Based on Palm Oil and Palm Olein

Recently, palm oil has become the second most consumed oil all over the world with a competitive price compared to other edible oils. Palm oil and its fractions, including palm olein, is accepted as a frying oil because of its tocopherols and carotenoids composition, and its relative proportion of unsaturated and saturated fatty acid content. However, due to its high melting point, it is not gaining due status in spite of being rich in natural antioxidants, vitamins, high oxidative stability and having a long self-life. Palm oil is also rich in β-carotene which helps to prevent liver and lung cancer. Number of studies have been conducted on blending palm oil with different vegetable soft oils in order to improve its cold stability at lower temperatures [5,11].

3.2.1 Palm Olein-canola oil and palm Olein-soybean blend

Another study has been conducted on blends of palm olein (PO) with canola oil (CO), sunflower oil (SF), and soybean oil (SO). The main aim of this work was to study the change in physical and chemical properties of such vegetable oils such as palm olein (PO), canola oil (CO), sunflower oil (SF), soybean oil (SO) when they are blended with one another in different mixing ratios. It is also aimed at finding a blend of oxidatively stable palm olein with low melting points by adding vegetable oils with high degrees of unsaturation. In this study, Oil blends were prepared by mixing palm olein with blending oil (w/w) in different ratios ranging from 10:90 to 90:10. The mixtures were stirred in a magnetic stirrer for 20 minutes for homogenization. The PV of the oils and their blends was determined in 8 week intervals while all the oil samples were kept in uncovered beakers at room temperature during this time. Canola-palm blend was found to be as low as 40 meq O2/kg oil. The initial PV value and after 3 weeks for palm olein-canola blends was found to be almost the same, although after 8 weeks it was lower than the others. The natural antioxidants in both palm and canola oil hinder the oxidation process considerably in this oil blend compared to the others. Also the results revealed that palm olein-canola blend has more resistance against oxidation and melting point, which was also found to be lower for this blend, followed by palm olein-soybean and palm olein-sunflower blends [13]. According to the FOA/WHO standards, the smart balance formulas for Palm olein: canola blends are within the ratios 60:40, 50:50, 40:60 and 30:70 (see Table 5).

3.2.2 Palm oil-Sesame blends

Another study was done on the effect of blending Palm oil with sesame oil in different ratios to get blends with low cost and better nutritional advantage relative to sesame. The ratios of blends used were (20:80) and (80:20) PO to SeO. A blend of PO with SeO is also prepared with saturated acid : Monounsaturated acid: Polyunsaturated acid (S:M:P) in ratio 1:1:1 in view of its nutritional significance. This can be achieved by blending with a ratio (52:48), PO to SeO. Studies were conducted on individual and blended oils to determine thermal stability at 180 ^{O}C in oven for 12 hours and during deep fat frying (DFF) of dry potato chips at 180 C for 9 hours. The individual and blended oils were analyzed for physio- chemical properties during thermal stability study including Iodine value (IV) acid value (AV), peroxide value (PV) and color. It was concluded from the study that the blends of PO with SeO in different proportions are more stable to oxidatuve deterioration due to heating as compared to SeO (see Table 6). The addition of PO to the SeO means longer frying times for the latter and could make the PO acceptable to the consumers who prefer foods with aroma and flavor impared by SeO. The protection affored by PO to SeO increased with increase in proportion of PO in blends [3].

Apart from protection advantage, blend with PO:SeO ratio 52:48, with its ideal fatty acid composition of 1:1:1 of SUFA:MUFA:PUFA, can offer a nutritional advantage frying medium (see Table 7).

3.3 Vegetable Oil Blends Based on Coconut

Coconut oil has been classified as functional food owing to its health beneficial properties. Coconut oil is composed predominately of medium-chain fatty acids (MCFA), also known as medium-chain triglycerides (MCT) (14-15%). MCFA are very different from LCFA. They do not have a negative effect on cholesterol and help to protect against heart disease. MCFA help to lower the risk of both atherosclerosis and heart disease. It is primarily due to the MCFA in coconut oil that makes it so special and so beneficial [14]. Due to the presence of MCFA, which are more soluble in water than LCFA.

Coconut oil is more prone to hydrolytic oxidation. Susceptibility of coconut oil to hydrolytic oxidation can be minimized by blending with other oils of more stability [14,15].

3.3.1 Coconut-palm olein and coconut-sesame blends

A study was done on the effect of blending coconut oil with palm olein and sesame oil. The objective of this study was to assess the acceptance of using coconut as a deep frying medium by blending it with sesame oil and palm olein, separately with the ratio 1:1, and to determine the stability and sensory quality of the blended oils during frying. The oil blends was prepared by a ratio (1:1).

Blends of coconut oil with sesame oil (blend 1); coconut olein with sesame oil (blend 2); coconut olein with palm olein (blend 3) in 1:1 (v/v) ratio—were used in this study for frying Poori, a traditional Indian fast food prepared from wheat flour. Changes in oil quality were determined by chemical and sensory methods. Free fatty acid content did not change whereas peroxide value increased. Anisidine value increased from 5.5, 0.9 and 4.2 to 34.3, 42.8 and 23.6 for blends 1, 2 and 3, respectively. Iodine value showed marginal decrease in blends 1 and 2. Diene value showed no change in all three blends (See Table 6). Sesamol content in blends 1 and 2, total tocopherols in all the three blends, and β-carotene.

Content in blend 3 decreased after frying. The blends showed a significant decrease ($P \le 0.05$) in the characteristic coconut oil odor after frying. Blend 3 showed comparatively better frying stability and also overall sensory quality of poori fried in this blend was the highest [15].

3.4 Vegetable Oil Blends Based on Cold Pressed Oils

The consumption of health-promoting products such as cold pressed oils may improve human health and prevent certain diseases [16].

3.4.1 Sunflower- and cold pressed oils

Blends (10% and 20%, w/w) of cold pressed oils including black cumin oil (BC), cumin oil (Cum), coriander oil (Cor) and clove oil (Clove) with high linoleic sunflower oil (SF) were formulated. Oxidative stability (OS) and radical scavenging activity (RSA) of SF and blends stored under oxidative conditions (60 °C) for 8 days were studied. By increasing the proportion of cold pressed oils in SF, linoleic acid level decreased, while tocols level increased. Progression of oxidation was followed by measuring peroxide value (PV), p- anisidine value (Av), conjugated dienes (CD) and conjugated trienes (CT). Inverse relationships were noted between PV as well as Av and OS at termination of storage.

Levels of CD and CT in SF and blends increased with increase in time. Cold pressed oil blends gave about 70% inhibition of DPPH• radicals. Oxidative stabilities of oil blends were better than SF, most likely as a consequence of changes in fatty acids and tocols' profile, and minor bioactive lipids found in cold pressed oils [16].

Blends consisting of sunflower oil and cold pressed tiger nut oil in different proportions were evaluated for various physicochemical parameters over 30 hours of frying process. The main objective of the study was to evaluate the effects of fatty acid compositions of tiger nut oil, sunflower oil and binary mixtures of them on the changes in physicochemical parameters of during deep frying process by assessing Free Fatty Acid (FFA), Peroxide Value (PV), thiobarbituric acid value (TBA value), iodine value, Total Polar Compounds (TPC), color and viscosity of the oils. Native and blended oils were heated at 180°C+5°C, then frozen French fries potato were fried every 30 min. Oil samples were taken every 5 hours and the entire continuous frying period was 30 hours. The results showed that phenolic content of cold pressed tiger nut oil was about 3.3 times higher than that of sunflower oil. The analytical data showed that the lowest deterioration during frying process occurred in tiger nut oil and the highest in sunflower. It also showed that tiger nut oil had higher level of total polyphenols which was 16.5 mg GAE per 100 g of oil compared to sunflower oil 5.0 mg GAE per 100 g of oil. At the same time, blending sunflower oil with various portions of tiger nut oil as a source of phenolic compounds and MUFA was suggested for improving the quality and the stability of sunflower oil during frying process. Our findings indicate that the changes of physicochemical parameters were controlled and significantly ($P<0.05$) decreased when tiger nut / sunflower oil (W/W) proportions were varied between 20/80 to 50/50. These blended oils had better stability against oxidation during deep fat frying process [17].

In spite of the great importance of the concept of blending in edible oil industry, there are still a lot of aspects that are not been totally studied and discussed for industrial scale applications. For example, limited study has discussed the use of rice bran and its blends as a stable frying medium. In a study that was conducted to compare between the oxidative stability of palm olein (PO), the most stable fat frying medium, and rice bran (RBO) regarding their oxidative stability, RBO showed better stability than the PO in deep frying of French fries [18]. Also, in spite of the health assumptions of the cold pressed oils, and the few studies that have been conducted on their stability, the use of edible oils based on cold –pressed oil has not been widely introduced for the industrial applications.

Because of the attention that have been given to health consequences related to fat dietary intake, there is an increased demand for exploring new fat mediums that can be of good health impact and at the same time of suitable for different food practices form salad dressing to frying.

3.5 Other Vegetable Seed Oils Having a Potential Future and Better Healthier Benefits

Japanese quince seed oil (*Chaenomeles japonica* (Thunb.) Lindl. ex Spach, family: Rosaceae) [19], obtained as a by-product of fruit processing, were characterized, and compared with nine well-known oils. The Japanese quince seed oil had the highest amounts of tocopherols, b-carotene and total phenolic compounds (726.20;10.77 and 64.03 mg/kg, respectively) and the lowest amount of chlorophyll (0.12 mg/kg) and peroxide value (0.59 mEq O2/kg) compared to sesame, poppy, peanut, flaxseed, pumpkin, sunflower, almond, hazelnut and walnut oils. In Japanese quince seed oil thirteen fatty acids were identified with three predominating: palmitic acid (10.07%), oleic acid (34.55%) and linoleic acid (52.35%). The highest consumer acceptance was noted for hazelnut and walnut oils, while it was lowest for the poppy and flaxseed oils.

Another potential health oil from seeds of H. sabdariffa and C. capsularis [20] which having oil content was 19.1 and 12.7%, respectively. The main three fatty acids of the oils from both species were – linoleic, oleic, and palmitic acid (over 95% of all). γ-Tocopherol consisted of over 65% of total tocopherol content of four detected homologues, in both species. Nine and ten sterols were detected in H. sabdariffa and C. capsularis seed oil, respectively. β-Sitosterol was the main sterol (over 50% of all). Lutein was the main carotenoid detected in both species. The total amount of tocopherols, carotenoids and sterols in C. capsularis vs. H. sabdariffa seed oil were 117.2 vs.159.2, 0.27 vs.0.74, and 247.1 vs. 968.0 mg/100 g oil, respectively.

Table 3. Oxidative stability of Sesame-rice bran and sesame-cotton seed oil blends after frying

No.		PV (meq./Kg)	p-A.V.	FFA%
1	Sesame: rice bran (80:20)	3.328± 0.058	8.306±0.602	1.09±0.010
	Sesame: rice bran (20:80)	4.580 ± 0.401	17.99±0.702	0.19±0.110
2	Sesame: cotton seed (80:20))	4.098 ±0.588	6.196±0.775	1.45±0.269
	Sesame: cotton seed (20:80)	4.057 ±0.231	6.636±0.376	0.13±0.144

Table 4. Smart balance formula for sesame: Rice bran blends

No	Oil Blend	Ratio	SFA ≤ 33%	MUFA	PUFA 20-36%	N-3 PUFA 1.7-6.6%	N-6 PUFA 8.3-30%
Mean Range			16.5%		28%	4.15%	19.15%
1	Sesame: Ricebran	80:20	19.2	33.6	27.2	1.2	26

Table 5. Smart balance formula for palm Olein: Canola blends

No.	Oil blend	Ratio	SFA ≤ 33%	MUFA	PUFA 20-36%	N-3 PUFA 1.7-6.6%	N-6 PUFA 8.3-30%
Mean Range			16.5%		28%	4.15%	19.15%
1	Palm Olein: Canola	60:40	30.6	50	19.4	4	15.3
2		50:50	26.5	52	21.5	5	16.5
3		40:60	22.4	54	23.6	6	17.6
4		30:70	18.3	56	25.7	7	18.6

Table 6. Physio-chemical characterization of Palm: sesame oils blends during thermal stability study

Oil/Blends	**Part-A initial values**			
	AV	**IV**	**PV**	**Color (Red)**
Palm pure	2.54	52.50	2.80	5.30
PO:SeO (80:20)	2.74	70.97	3.50	5.80
PO: SeO (20:80)	3.05	86.96	5.70	6.70
PO:SeO (52:48)	3.50	96.29	6.80	7.20
Sesame pure	3,72	111.79	3.363	7.90
	Part-B Fianl value			
	AV	**IV**	**PV**	**Color**
Palm Pure	3.24	51.10	3	5.89
PO:SeO (80:20)	3.45	69.09	3.75	6.60
PO: SeO (20:80)	3.78	84.66	6.11	7.80
PO:SeO (52:48)	4.30	93.79	7.30	8.60
Sesame pure	4.50	108.89	3.90	9.70
	Part C-Difference			
Palm Pure	**Δ AV (%)**	**Δ IV(%)**	**Δ PV(%)**	**Δ Color(%)**
PO:SeO (80:20)	27.55	2.66	7.14	11.13
PO: SeO (20:80)	25.91	2.67	7.14	13.79
PO:SeO (52:48)	23.93	2.64	7.19	16.41
Sesame pure	22.85	2.59	7.35	19.44

Table 7. Smart balance formula for palm oil: sesame blends

No.	Oil Blend	Ratio	SFA ≤ 33%	MUFA	PUFA 20-36%	N-3 PUFA 1.7-6.6%	N-6 PUFA 8.3-30%
Mean Range			16.5%		28%	4.15%	19.15%
1-	Palm Oil: Sesame Oil	52:48	32.58	40.52	27.16	0.15	26

Table 8: Change in chemical parameters of coconut oil blends during frying

Sample	No of fryings	FFA%	PV(meqO2/Kg)	IV (Wijs)	AV	Diene(%)
Blend 1	0	0.9	0	59.2	5.5	0.2
	5	0.9	1.8	57.8	19.2	0.2
	10	1.0	3.2	57.8	23.7	0.2
	15	1.0	6.2	55.4	34.4	0.3
Blend 2	0	1.6	1.6	57.9	0.9	0.2
	5	1.6	3.7	56.7	18.5	0.2
	10	1.5	4.3	56.0	32.3	0.2
	15	1.6	5.4	55.8	42.8	0.3
Blend 3	0	0.5	6.3	35	4.2	0.2
	5	0.6	5.2	36.1	21.4	0.1
	10	0.6	8.3	36.2	22.6	0.2
	15	0.6	11.2	36.5	23.6	0.2

Table 9. Oxidative stability of sunflower blended with different portions of tiger nut oil after 30 hr frying at 180°C

Oxidative test	Tiger nut oil (TNO)	Sunflower oil (SO)	TNO+SO				
			10:90	20:80	30:70	40:60	50:50
PV (meq.O2/Kg)	6.51	9.64	8.98	8.41	7.63	7.44	6.76
TPC (%W)	13.61	19.40	18.00	16.92	15.95	14.46	14.32
Viscosity (mPa-S at 30 °C0	59	70.50	65.00	64.00	62.50	61.00	60.10
Red color	14.50	17	16.50	15.50	15.50	15	14.50
Thiobarbituric acid value	0.55	0.97	0.81	0.73	0.70	0.65	0.61

The composition of fatty acids and phytosterols of oils recovered from the seeds of nine industrial fruit by-products: watermelon (*Citrullus lanatus*), honeydew melon (*Cucumis melo*), sea buckthorn (Hippophae rhamnoides), red currant (*Ribes rubrum*), pomegranate (*Punica granatum*), Japanese quince (*Chaenomeles japonica*), grape (*Vitis vinifera*), gooseberry (*Ribesuva-crispa*) and apple (*Malus domestica*) were studied (21). The oil yield in the investigated fruit seeds ranged from 11.8% (*Sea buckthorn*) to 28.5% (*Watermelon*). The main phytosterol identified in all fruit seed oils was β-sitosterol with the concentration ranging between 0.5 and 3.1 mg/g of oil, in watermelon and Japanese quince, respectively. The fatty acid composition was unique for each fruit seed oil. The majority of samples had high linoleic acid content (38.0–70.7%), whereas the pomegranate seed oil was extremely rich in punicic acid (86.2%).

4. CONCLUSION AND FUTURE PROSPECTIVE

In conclusion, the Optimum selection of oil blend which having the balanced fatty acid compositions,in addition to the right fatty acid types which are naturally more stable when subjected to drastic cooking and frying conditions in domestic applications , is very cost effective technique for oil producers to produce a healthier and functionally durable general purpose cooking & frying oils aimed at improved and extended physical, chemical and functional properties. It is clear from the above studies that the oxidative stability, iodine value and peroxide value can be improved in this way to get good and desirable blends which will help to provide precise stability data. For example, the stability of unsaturated vegetable oils can be increased by blending with stable oil that has high saturation.

In spite of the great importance of the concept of the above optimum blending ratios between different types of vegetable oils edible oil industry to achieve the optimum healthier and functional oil blend, there will be still a lot of work to be done to explore a single oil type which naturally carry these benefits with no blending with other oils and be available to oil producers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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