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EVALUATION OF THE PHYSICO-CHEMICAL STABILITY OF RICE BRAN OIL AND ITS BLENDS FOR THE DEVELOPMENT OF FUNCTIONAL MEAT PRODUCTS

K. Jalarama Reddy*, K. Jayathilakan, M.C. Pandey and K. Radhakrishna
Freeze Drying and Animal products Technology, Defence Food Research Laboratory, Siddarthanagar, Mysore.

*Corresponding Author: jalaramareddy@gmail.com

ABSTRACT

Rice Bran Oil (RBO) has highest quality among other oils in terms of shelf life, fatty acid profile, cooking quality, sensory attributes, nutritive value and oxidative stability. RBO is an abundant source of primary antioxidants including Gamma-Oryzanol, alpha, beta, gamma and delta tocopherol isomers, as well as the most active antioxidants, the tocotrienols. Even though RBO is a good source of antioxidants and ω-6 fatty acids, for attaining an ideal recommended fatty acid profile (ω-6/ω-3) it has to be blended with oils rich in ω-3 fatty acids. Since Flaxseed oil (FSO) is a good source of ω-3 fatty acids and to establish its stability with RBO, the present study was carried out for evaluation of physico-chemical stability of different blends of RBO with FSO. Physico-chemical markers like TBARS, Totox value, Anisidine value, Peroxide value, Free fatty Acids, Iodine value and Hunter color values (L, a* and b* values) were evaluated for the designed blends at different storage temperatures (Ambient 30±2 ^{o}C & 45^{o}C). Significant increase ($p<0.05$) in rancidity parameters have been observed with FSO during storage at both temperatures. Even though RBO and its blends exhibited an increase in rancidity values, it was not significant ($p>0.05$). The blend with 90 % RBO and 10% FSO has the fatty acid profile nearer to the ideal recommended ratio as SFA/MUFA/PUFA ratio as 1:1.9:1.8 and ω-6/ ω-3 as 4:1. Evaluation of the L, a* and b* values indicated significant ($p<0.05$) increase in lightness during storage of FSO but other indexes did not show any significant ($p>0.05$) variation in all the blends. Due to functional properties of RBO, it is gaining lot of interest in the development of meat products. The proper utilization and promotion of RBO as health oil remains the most important factor in increasing its acceptability as cooking medium in development of Meat based super foods.

Keywords: Rice bran oil, Flaxseed oil, Totox value, Lipid oxidation, Fatty acid profile.

INTRODUCTION

Rice Bran Oil (RBO) extracted from bran of rice has been used extensively in Asian countries such as Japan, Korea, China, Taiwan, and Thailand (Kahlon et.al., 1992). Due to its nutraceutical and nutritional profile this is the preferred oil in many countries. More recently, interest in RBO escalated with its identification as a ''healthy oil'' that reduces serum cholesterol (Cheruvanky et.al., 2003). RBO is an abundant source of primary antioxidants including Gamma-Oryzanol, alpha, beta, gamma and delta tocopherol isomers, as well as the most active antioxidants, the tocotrienols. RBO has a composition similar to that of peanut oil, with 38% monounsaturated, 37% polyunsaturated, and 25% saturated (Orthoefer, 2005) and also it contains good quantity of antioxidant compounds like tocopherol at 81 ppm, 336 ppm of tocotrienols and 2000 ppm of oryzanol (www.californiariceoil.com).

RBO utilization in foods, pharmaceuticals and cosmetics applications is increasing now days. (Naivikul et.al., 2008) Due to its high flavour and oxidative stability than other oils it is used as frying oil in food preparations. Trans fatty acids are reported to be very low in this oil (Orthoefer et.al., 2004). The high stability of RBO as a frying oil is attributed in part to its γ-oryzanol content. Studies (Nystrom et.al., 2007) reported that the γ-oryzanol degraded at a slower rate than α-tocopherol and these compounds did not exert a synergistic effect as antioxidants. RBO is vastly superior to traditional cooking oils and can be considered nutraceutical oil that is perfect for all healthy cooking needs. RBO is quickly becoming a favourite in commercial frying to replace hydrogenated oils that contain trans fat. RBO is regarded as highest quality among other oils in terms of shelf life, fatty acid profile, cooking quality, sensory attributes, nutritive value and oxidative stability. RBO could be the solution to the ever increasing metabolic syndrome cases in the world. This oil is a unique edible oil; with many nutritional benefits, as compared to other edible oils. Flaxseed (*Linum usitatissimum*) is the richest dietary source of plant lignans, where secoisolariciresinol diglucoside (SDG) is approved as a lipid-lowering agent (Patade et.al.,2008). Flaxseed oil (FSO) contains about 53.3% of α-Linolenic acid (ALA) and 12.7% of Linoleic acid (LA), yielding the highest n-

3/n-6 FA ratio amongst plant sources (NRCCFI, 1993). FSO is the richest source of valuable Omega-3 essential fatty acid (EFA).

Many of the recent studies highlighted the health benefits of FSO for the cardiovascular (CVD) and skeletal systems (Griel et.al., 2007) and also in inflammatory conditions like rheumatoid arthritis, psoriasis, and ulcerative colitis (Mantzioris et.al., 1994). A high intake of long chain omega-3 PUFAs like docosahexaenoic acid (DHA, C22:6n-3) and eicosapentaenoic acid (EPA, C20:5n-3) lowers the CVD. A healthy diet should consist of roughly 2 - 4 times fewer omega-6 fatty acids than omega-3 fatty acids, however the typical American diet, tends to contain about 14 - 25 times more omega-6 fatty acids than omega-3 fatty acids. Several research studies showed intake of insufficient Omega-3 fatty acids is a significant factor in the rising rate of inflammatory disorders in the United States. Blending of different edible vegetable oils gives the manufacturer greater flexibility to tailor the products to accomplish specific functional properties and also to satisfy nutritional requirements. However, importantly blending does not result in the chemical modification of the triacylglyceride composition. Nutritional advantages have been identified for oils rich in oleic and other monounsaturated fatty acids (MUFA) with reduced linoleic acid and saturated fatty acids (Nestel et.al., 1994).

Fatty acid profile of oils can also be improved by blending; so, the need to hydrogenate unsaturated oils is appreciably decreased, thereby eliminating the chances of formation of harmful trans-fatty acids. Blending of different types of vegetable oils increases the levels of bioactive lipids and natural antioxidants and better quality oils are produced, which include tailor-made physicochemical properties, as well as improved nutritional value at economical prices. Oil blends have been a common permitted practice in many countries. Blending of vegetable oils and fats has emerged as an economical way of modifying the physicochemical characteristics of vegetable oils, apart from improvement in oxidative stability (Anwar et.al., 2007). Nowadays food habits around worldwide are mainly based on deep fried and baked foods for which oxidative-resistant oils has to be used. But, conventionally available cooking oils cannot fulfil this requirement; rather, some oils may cause serious health disorders due to the generation of hazardous oxidation products. This requirement can be conveniently met through the blending process. Corn, sunflower and soybean oils with high levels of PUFA are the main oils used for cooking and frying. However, these oils are not quite suitable for frying due to the higher magnitude of oxidation at elevated temperatures (Anwar et.al., 2007).

The oxidation stability of a blend depends strongly on those of its individual oil partners (Isbell et.al., 1999). Several research works has been carried out on the stability of RBO and its blend with other edible vegetable oils such as groundnut oil, sunflower oil and mustard oil and concluded that oil blends showed good stability (Shiela et.al., 2004, Sharma et.al., 2008). Comparative studies on the physical properties of vegetables oils and their blends after frying showed a reduction in peroxide value when using blended oils (Susheelamma et.al., 2004). Blended oils are gaining importance worldwide due to the advantages they offer such as improved thermal stability, oxidative stability; nutritional benefits (Sharma et.al., 1996) and also fulfils specific desired properties which will be used for the development of functional food products. The various advantages of blended oils and increased market demand raised the need for a rapid and simple technique for quantifying the proportion of specific oil in a blend based on their stability and physico-chemical quality parameters. Information currently available on stability characteristics of RBO Blend with FSO is deficient and full investigations on quality characteristics of edible oil blends are long overdue. This present investigation describes the stability characteristics of blends of RBO and FSO to increase its value and contribution to the development of newer functional meat and poultry products with ideal fatty acid profile in terms of SFA:MUFA:PUFA and n-6:n-3 and for nutraceuticals applications.

MATERIALS AND METHODS

RAW MATERIALS

The Rice bran oil used in present investigation was obtained from Habib Agro Industries, Mandya, Karnataka, India and Flaxseed oil obtained from SSS Industries, Bangalore, India.

CHEMICALS AND REAGENTS

All the reagents and chemicals used for the study were of Analar® grade and procured from M/s Sigma Chemicals, Corporation, USA and M/s BDH Company. The standard fatty acid methyl esters used in the estimation of fatty acids by Gas chromatography and the BF_3 - CH_3OH used in the esterification were obtained from Sigma Chemicals Corporation, USA.

DESIGNING OF OIL BLENDS AND STORAGE STUDIES

RBO samples were blended with FSO at different ratios using homogenized mixer. The samples were stored at two different temperatures (Ambient (30±2 ^oC & 45^oC) and physico-chemical quality markers were evaluated periodically at every 30 days interval for 3months.

Sample codes A-100 % RBO
B- 95 % RBO+5% FSO
C- 90 % RBO+10% FSO
D-85 % RBO+15% FSO
E- 80 % RBO+20% FSO
F-100% FSO

ANALYSIS OF SAMPLES

Peroxide value (PV) (AOCS, 1998), Free Fatty acids (FFA) (AOCS, 1993), Thiobarbituric Acid Reactive substance (TBARS) (Taraldgis et.al, 1960), Iodine Value (IV) (AOCS, 2004) and Anisidine value (AV) (AOCS, 1998) were determined by using standard methods.

TOTAL OXIDATION (TOTOX) VALUES

Total oxidation (TOTOX) values (Akoh, 1998) of oil samples were determined using the following equation
Total oxidation (TOTOX) value = (2 × PV) + AV.

EVALUATION OF COLOR CHARACTERISTICS (L, a* and b* VALUES)

Color values of the oil blends initially and during storage were determined using Hunter colorimeter (Color Flex, CFLX-45-2, Hunter lab, Reston, VA,USA) in terms of *L*, *a** and *b** values as per the procedure (Shand et.al., 2000). Measurement of the color co-ordinates were determined using a D-65 illuminant with a spectral range of 400-700nm and a spectral resolution of 10nm after standardizing the sensor using standard black and white colored tiles. *L* value in the Hunter measurements indicates lightness or darkness, *a** value indicates the color co-ordinate with respect to redness and greenness, while *b** stands for the shift of color between yellow to blue.

TOTAL FATTY ACID PROFILE OF SAMPLES BY GAS CHROMATOGRAPHIC METHOD

Fatty acid composition of the oil samples were determined by Gas chromatography as fatty acid methyl esters using standard esters of fatty acids.

ESTERIFICATION OF FATTY ACIDS

The oil samples were esterified as per the procedure (Metcalf et.al., 1966) with slight modifications. About 150 mg of lipid was accurately weighed into a clean and dry stoppered test tube. Four millilitres of 0.5 N alcoholic sodium hydroxide solutions was added and heated for 5 min over a water bath at 90^{o}C. On cooling, 5 ml of boron tri-fluoride methanol reagent was added and heated for 5 min at 90^{o}C over a water bath, followed by addition of 10 ml of saturated sodium chloride solution. The samples were thoroughly cooled to room temperature and 5 ml hexane was added to each tube. It was shaken well and kept undisturbed. The upper hexane layer was drawn out into clean dry conical flask and dried over anhydrous sodium sulphate to remove the traces of moisture if present. The samples were filtered and transferred to stoppered clean dry tubes for gas chromatographic analysis.

TOTAL FATTY ACID ANALYSIS BY GAS CHROMATOGRAPHY

Analysis of total fatty acids was carried out by a Ceres-800, Chemito model gas chromatograph fitted with BPX 70 column (25 m, 0.32 mm ID) and flame ionization detector. Temperature gradient programming was employed from 150 to 220 ^{o}C. Split ratio was adjusted to 1:25 and capillary flow of carrier gas to 2.0 ml/min. Injector and detector port temperatures were adjusted as 230^{o}C and 240^{o}C respectively. For FID, hydrogen and oxygen were used and the flow was adjusted as 45 ml/min and 450 ml/min respectively. Along with samples, standard esters of fatty acids (Sigma chemical company, St. Louis, USA.) were also injected and the fatty acids were detected by comparing the retention time of the standard esters of fatty acids. The quantification of the fatty acids was carried out by evaluating with the standard fatty acid esters area corresponding to each peak in the chromatogram. Iris-32 software was used to integrate and evaluate the chromatogram in the analysis.

STATISTICAL ANALYSIS

The data obtained were subjected to analysis of variance (ANOVA) and Duncan's multiple range test to evaluate the statistical significance of the treatments and significance was established at $p<0.05$.

RESULTS AND DISCUSSION

EVALUATION OF THE PEROXIDE VALUES (PV)

Evaluation of the oxidative stability of different blends of oils stored at ambient (30±2 ^{o}C) and 45 ^{o}C were carried out and expressed in terms of peroxide values in Fig 1. Peroxides are the primary oxidation products and its concentration may fluctuate over time since peroxides turn to other oxidation products in time. Primary oxidation processes in oil mainly from hydro peroxides, which are measured by the PV. In general, lower the PV, the better the quality of the oil. However PV decreases as secondary oxidation products appear (Chakrabarty, 2003). From the Fig 1, it could be observed that significant difference ($p<0.05$) in peroxide values were found out between RBO and FSO at ambient (30±2 ^{o}C) as well as at 45 ^{o}C storage. This could be due to the higher unsaturation that is present in FSO in terms of n-3 fatty acids (Vaissey, 1997). The PV of the blends stored at ambient (30±2 ^{o}C) and 45 ^{o}C did not make any significance difference ($p>0.05$) at both temperatures of storage indicating the contributory effects of antioxidants naturally present in RBO in inhibiting the oxidative rancidity (Orthoefer, 2005) PV of different oil blends stored at ambient (30±2^{o}C) and 45^{o}C for 3 months showed a progress increase with storage period. Steady increase in the blends according to the extent of oxidation caused by the formation of hydro peroxides during fat oxidation was observed. Peroxides are possibly not directly responsible for the taste and odour of rancid fats, their concentration as represented by the PV is often useful in assessing the extent to which the rancidity has advanced. Fresh oils usually have peroxide values below10 meq/kg, and a rancid taste often begins to be noticeable when the PV is above 20 meq/kg (PFA, 2005). Though, there is a progressive increase in PV up to 3 months of storage, it did not exceed the limits specified by PFA in the blends. Research studies (Schnepf, 1991) on the changes in PV of edible oils during storage revealed that the changes in PV used to be slow but consistent throughout.

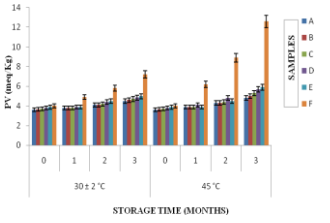

Figure 1: Peroxide values for blended oil samples at different temperatures of storage

p-ANISIDINE VALUES (AV)

The secondary stage of oxidation occurs when the hydro peroxides decompose to form carbonyls and other compounds, in particular aldehydes. This gives the oil a rancid smell and they are measured by the AV. The lower the AV, the better the quality of the oil. Anisidine value (AV) represents the level of non-volatile aldehydes, primarily 2-alkene present in the fat. Generally AV will increase as aldehydes are produced and then decrease when the aldehydes reach a certain level and subsequently are further oxidized or participate in demonization or condensation reactions (Schnepf, 1991). The AV test is particularly useful for oils of low peroxide value (PV) and for assessing the quality of highly unsaturated oils. The test involves a condensation reaction between the conjugated dienals or 2-alkenals and p-anisidine to form colored products. Anisidine value determination is a quality marker for evaluating the quality of oils and fats. RBO, FSO and its blends initially and during storage were subjected for AV analysis and the values obtained are depicted in Fig 2. From the data it is clearly visualized that significant increase ($p<0.05$) in AV has been found with respect to FSO stored at both temperatures after 3 months of storage. But in the case of RBO and its blends with FSO did not show any significant ($p>0.05$) variation in AV values during storage at both temperatures indicating greater oxidative stability due to the Presence of natural antioxidants in RBO (Orthoefer et.al., 2003).

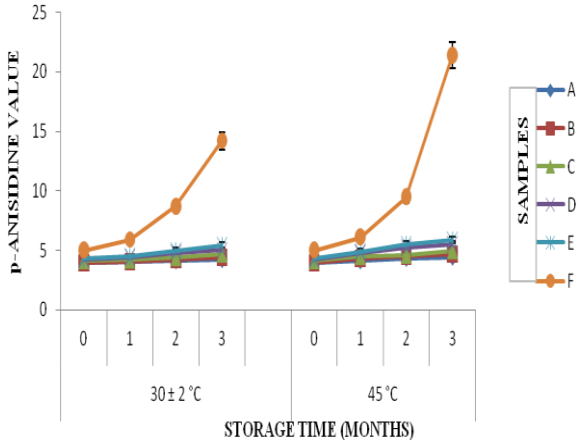

Figure 2: Anisidine values for blended oil samples at different temperatures of storage

TOTAL OXIDATION (TOTOX) VALUES

The Totox value is calculated by the formula AV + 2PV to indicate oils overall oxidation state. The lower the Totox value, the better the quality of oil. Totox value represents total description of the oil/fat quality, oxidation status and presence of degradation products formed from previous oxidation. The para-anisidine value is often used in conjunction with peroxide value to calculate the so called total oxidation or Totox value (Akoh, 1998). From the discussion with regard to the data obtained in the case of PV and AV (Fig 1 & 2) same trend in the parameters were observed during storage of RBO, FSO and its blends at different temperatures. The values were subjected for Totox value calculation to obtain a better picture of the overall oxidative profile of the oil blends. The calculated values are reflected in Fig 3. From the fig 3, it could be observed that significant difference ($p<0.5$) is existing between RBO and its blends with FSO.

FREE FATTY ACIDS (FFA)

Hydrolytic processes lead to the formation of free fatty acids by splitting of acylglycerols that can affect flavor. Free fatty acids are important quality indicators during processing and storage of fats and oils. Generally oils are susceptible to enzymatic hydrolysis; the FFA formed varies with age and storage. Free fatty acid determination is a quality marker for establishing the extent of hydrolytic rancidity in oils and fats. RBO, FSO and its blends initially and during storage were subjected

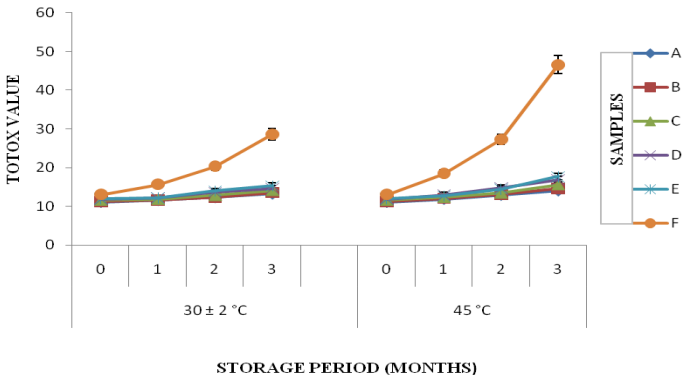

Figure 3: Totox values for blended oil samples at different temperatures of storage

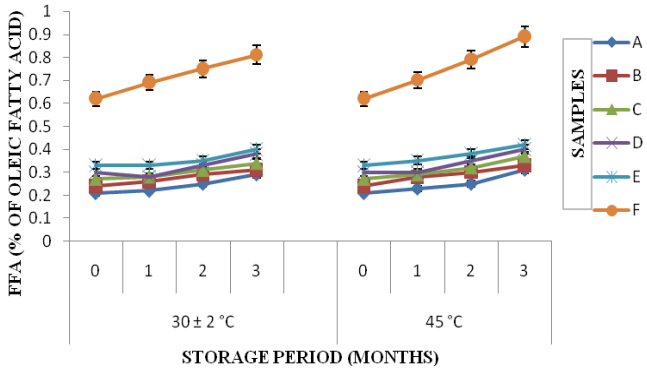

Figure 4: FFA content in blended oil samples at different temperatures of storage

for FFA analysis and the values obtained are depicted in Fig 4. From the data it is clearly visualized that significant increase ($p<0.05$) in FFA has been noticed with respect to FSO stored at both temperatures after 3 months of storage and it is exceeding the limit of 0.8 prescribed by BIS (BIS, 1995). The increase in FFA could be attributed to the hydrolysis of triglycerides, triggered by the moisture from the oils and due to oxidation. The presence of moisture can cause other deteriorative chemical reactions leading to hydrolytic rancidity. But in the case of RBO and its blends with FSO did not show any significant ($p>0.05$) variation in FFA values during storage at both temperatures indicating greater oxidative and hydrolytic stability

because of the presence of Oryzanol and trienols (Nystrom et.al.2007). Several studies carried out on the hydrolytic and oxidative stability of other oil blends (Semwal ET.AL., 2001; Padmavathy et.al., 2001) revealed same type of trend observed with FSO and RBO.

IODINE VALUES (IV)

IV ("iodine adsorption value" or "iodine number" or "iodine index") measures the number of reactive double bonds present in oil. A higher IV number indicates more double bonds in the sample and therefore that greater care will be needed to slow down oxidation. IV is not a measure of quality but is an indicator of oil composition. Data on changes in the IV of the oil blends during storage is shown in Fig 5. It was observed that IV decreased gradually during storage but significant difference ($p>0.05$) was observed in RBO and its blends with FSO. Rapid changes in IV of oil blends may be attributed to propagation of auto - oxidation process where hydro peroxides are formed from free radicals and fatty acids generated in initiation stage or auto oxidation reaction. The results of the present study are in agreement with an earlier study (Semwal, 2001).

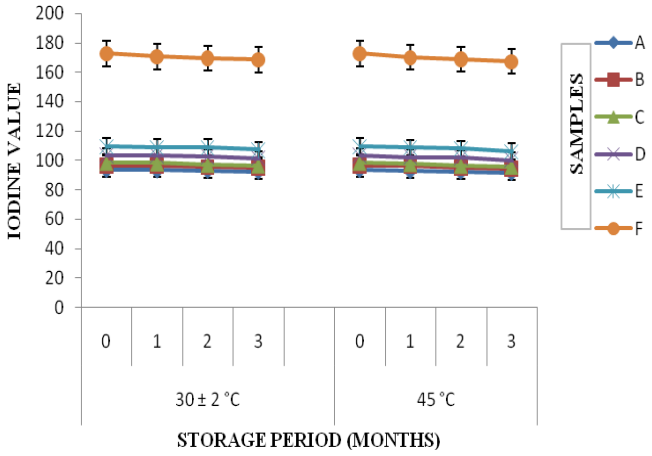

Figure 5: Iodine Values for blended oil samples at different temperatures of storage

THIOBARBITURIC ACID REACTIVE SUBSTANCE (TBARS)

The TBA value is a method to investigate secondary oxidative aldehyde products, usually in PUFA. The TBA value of RBO, FSO and its blends during storage at different temperatures were evaluated for TBARS and the values obtained were represented in Fig 6. Significant increase in TBA values has been noticed during storage in FSO at ambient and 45 ^{o} C temperature in comparison with RBO and its blends. From the IV represented in Fig 5 it was clear that FSO was having a high IV of 172 in Comparison with RBO having IV of 93. Because of this higher unsaturation levels it may be more prone for oxidation and formation of compounds which will contribute towards the increase in TBA number. Due to the natural presence of several antioxidants in RBO it may be giving a protective effects in blends against lipid oxidation and thus in RBO and blends the observed values are not significantly different ($p>0.05$). The results clearly indicate the stabilising effect of RBO in comparison with other edible oils towards the oxidative deteriorative changes. The results of the present study are in agreement with that of earlier studies (Semwal, 2001), who reported the TBA values on storage for a few oil blends.

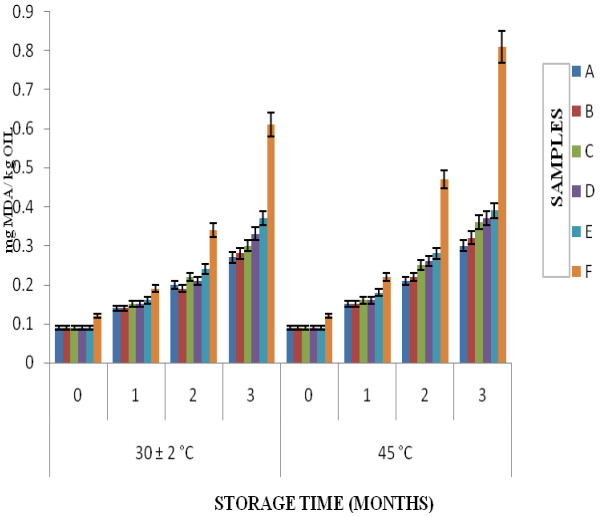

Figure 6: Thiobarbituric acid (TBA) value for blended oil samples at different temperatures of storage

EVALUATION OF COLOR CHARACTERISTICS (L, a* and b* VALUES)

Color is a sensory property with a strong influence on food acceptance as it contributes decisively to the initial perception that one can acquire of the condition, ripeness, degree of processing, and other characteristics of foods (Alos et.al., 2006). Appearance of oil can be an indicator for assessing the overall quality and out of this evaluation of the color indexes can be considered as an important physical parameter. The different oil blends of RBO and FSO during storage were examined for its color profile in terms of L, a* and b* values and the same has been reflected in Table 1. From the values it could be assessed that the L values are significantly increasing ($p<0.05$) during storage at ambient and 45 ^{o}C in the case of FSO when compared with RBO and Other blends. In the case of other two color indexes a* and b*, no significant ($p>0.05$) changes has been noticed in all the samples during storage at both the temperatures. The natural color of FSO is deep amber to reddish brown depending on the variety and RBO is having a light yellow color. Usually the pigments like carotenes, chlorophylls and some Maillard browning products contribute color of the oils (Juliano et.al., 1995). The variation in L values observed in the case of FSO in the study may be due to the degradation of pigments. The presence of antioxidants as discussed earlier might be contributing towards the stability of pigments in RBO and its blends during storage as indicated in the non significant changes in L values in Table 1.

Table 1 - Color characteristics for blends (L, a* and b* values)

Hunter color values	Samples	Storage period (Months)						
		RT				45 °C		
		0	1	2	3	1	2	3
L	A	3.21	3.03	3.5	4.2	3.91	4.51	4.86
	B	3.53	4.32	4.26	4.76	4.74	5.28	5.64
	C	3.01	3.37	4.8	5.4	4.28	5.66	5.97
	D	3.52	4.68	5.01	5.69	4.94	5.31	6.10
	E	3.45	4.32	5.45	6.04	4.73	5.57	6.02
	F	1.65	3.55	7.8	8.31	4.63	7.8	10.57
a*	A	-1.63	-1.02	-0.46	-0.27	-1.4	-2.19	-1.04
	B	-1.47	-0.36	0.45	0.69	-0.7	-1.94	-1.02
	C	1.06	-1.36	-0.12	0.12	-0.33	-0.92	-0.41
	D	-1.24	-0.7	-0.45	-0.23	-0.83	-0.68	-0.33
	E	-0.8	-0.89	-0.95	-0.54	-0.25	-1.25	-1.38
	F	-0.48	0.31	0.21	0.34	0.52	0.21	0.34
b*	A	1.48	0.57	0.21	0.87	6.57	2.65	2.85
	B	0.51	1.31	0.73	0.72	2.21	3.44	3.34
	C	0.71	0.4	0.69	0.65	2.92	1.84	1.26
	D	1.08	1.56	0.05	0.41	3.34	1.08	1.42
	E	0.87	1.3	0.22	0.61	2.32	1.74	1.85
	F	1.19	0.98	0.81	0.57	0.43	0.81	1.34

Values represented in the Table are Mean of 3 experiments

Table 2: Ratio of SFA/MUFA/PUFA and n-6/n-3 of RBO/FSO /blends by GLC

Storage Period	Samples	SFA (%)	MUFA (%)	PUFA (%)	SFA / MUFA / PUFA	n-6 (%)	n-3 (%)	n-3/ n-6
INITIAL	A	22.00	43.71	34.24	1:1.9:1.5	32.05	2.1	1:15
	B	21.40	42.59	35.91	1:1.9:1.6	31.04	4.79	1:6.4
	C	20.80	41.48	37.65	1:1.9:1.8	30.02	7.49	1:4.0
	D	20.20	40.37	39.34	1:1.9:1.9	29.04	10.18	1:2.8
	E	19.60	39.26	41.06	1:2.0:2.0	28.13	12.88	1:2.1
	F	10.00	21.52	68.50	1:2.2:6.8	12	56	1:0.21
3 months (Ambien30± 2 °C temperature)	A	22.10	43.40	34.15	1:1.9:1.5	32.01	2.04	1:15.6
	B	21.49	42.28	35.74	1:1.9:1.6	30.93	4.45	1:6.9
	C	20.87	41.16	37.39	1:1.9:1.7	29.85	6.86	1:4.3
	D	20.28	40.04	39.04	1:1.9:1.9	28.77	9.27	1:3.1
	E	19.66	38.93	40.69	1:1.9:2.0	27.69	11.68	1:2.3
	F	10.91	21.05	67.24	1:2.0:6.1	10.41	50.24	1:0.2
3 months (45 °C temperature)	A	22.82	42.83	33.90	1:1.8:1.4	31.92	2.03	1:15.7
	B	22.19	41.68	35.50	1:1.9:1.6	30.75	4.16	1:7.3
	C	21.53	40.56	37.13	1:1.9:1.7	29.58	6.3	1:4.6
	D	20.89	39.44	38.71	1:1.9:1.9	28.42	8.44	1:3.3
	E	20.56	38.32	40.31	1:1.9:2.0	27.25	10.58	1:2.5
	F	12.41	20.44	62.97	1:1.6:5.3	8.61	44.81	1:0.2

Values are mean ±S.D (n=3)

FATTY ACID PROFILE

Several studies are being conducted with respect to the stability and fatty acid profile of different oil blends which have immense functional potential for the application of the development of meat and poultry products. Achieving an ideal SFA/MUFA/PUFA and n-6/n-3 ratio and a good stability of edible oils and its potential in the development of functional meat products is a challenging task to meat chemists. Since RBO and FSO are reported to be good sources of n-6 and n-3 fatty acids respectively, studies have been conducted to establish the ratio of n-6 and n-3 and the shelf stability during storage in

terms of fatty acid profile by GLC technique. Table 2 shows the ratio of SFA/MUFA/PUFA and n-3/n-6 established by Gas liquid chromatography initially and during storage of the different blends in discussion.

The oil blend of 90 % RBO with 10 % FSO has SFA/MUFA/PUFA and n-6/n-3 ratio as 1:1.9:1.8 and 4:1 respectively which is closer to the ideal lipid profile as recommended by American Heart association and WHO (Usha, 2001). However, the other oil blend samples (D & E) are having n-6/n-3 ratio less than 4:1 and this blends also have been recommended special conditions to overcome several harmful disorders related to fatty acids. During the three month storage at both temperatures the samples exhibited an insignificant ($p>0.05$) increase in SFA content and decrease in MUFA and PUFA content in oil blends of A,B, C, D and E. Significant degradation ($p<0.05$) of Omega-3 fatty acids was observed after 3 months of storage in FSO and from the data represented in Table 2, it was found that the ratio of SFA/MUFA/PUFA and n-6/n-3 were significantly ($p<0.05$) altered. The main substrate for lipid oxidation is considered to be the unsaturated fatty acids. Compared to RBO, the unsaturation is more in FSO in terms of omega-3 fatty acids. Moreover RBO is considered to be stable due to the presence of natural antioxidants like Oryzanol, tocopherol and tocotrienols. This may be the reason for the degradation of the fatty acids in FSO during storage as reflected in Table 2. From the data it was clear that RBO is giving a protective effect in the degradation of unsaturated fatty acids in the blends with FSO.

CONCLUSION

RBO and FSO are two important edible oils which has got good functional properties and health benefits. These oils contain lot of unsaturated fatty acids in terms of omega-6 and omega-3. Stability of FSO is always a concern for food technologists for its application in the development of meat and poultry products. Studies established the feasibility of preparation of stable oil blends with RBO and FSO which can be employed for the development of functional meat products. FSO as such exhibited poor stability characteristics as indicated in the oxidative and hydrolytic rancidity parameters established in the study. The blends of RBO and FSO did not exhibit significant changes in comparison with RBO in terms of the chemical parameters studied. Blending of these oils yielded a functional, health promoting designed oil medium which can deliver an ideal lipid profile in terms of SFA/MUFA/PUFA and n-6/n-3 ratios. 90 % RBO and 10 % FSO blend exhibited a lipid profile which is more nearer to the recommendations of AHA and WHO and will have more applicability in developing functional meat and poultry products which will have great potential in civilian and Armed forces.

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