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Thermal behavior of pure rice bran oil, sunflower oil and their model blends during deep fat frying

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RESUMEN

Comportamiento en fritura del aceite de salvado de arroz, aceite de girasol y mezclas de ambos aceites

La mezclas de aceites pueden ofrecer algunas ventajas sobre los aceites puros las como mejor calidad nutricional, coste inferior o mayor estabilidad durante el almacenamiento. En este estudio, aceite de salvado de arroz (RBO), aceite de girasol (SFO) y mezclas de ambos, se sometieron al proceso de fritura de patatas y se evaluaron los principales cambios físico-químicos en los aceites puros y en sus mezclas (acidez, índice de yodo, color, índice de peróxidos y composición de ácidos grasos). Aunque todas las muestras mostraron buena estabilidad a elevada temperatura, los mejores resultados se obtuvieron con la mezcla que contenía 60% de RBO y 40% de SFO.

PALABRAS-CLAVE: Aceite de girasol - Aceite de salvado de arroz - Comportamiento térmico - Mezclas de aceite.

SUMMARY

Thermal behavior of pure rice bran oil, sunflower oil and their model blends during deep fat frying

Shall be deleted offer some advantages like better nutritional quality, lower cost and greater storage stability than pure oils. Model blends prepared from pure rice bran oil (RBO) and sunflower oil (SFO) were examined for change in their physico-chemical parameters (acid value, iodine value, color value, peroxide value and fatty acids). Repeated deep fat frying processes were carried out using dried potato chips in pure rice bran oil, sunflower oil and their model blends, in order to study the thermal behavior of pure rice bran oil, sunflower oil and their model blends. Pure rice bran oil and sunflower oil showed good thermal stability during the repeated deep fat frying cycles. Although all the blended oils used in the study showed good thermal stability during repeated deep fat frying cycles, model blends consisting of 60%RBO + 40% SFO showed better suitability during repeated deep fat frying than the remaining blended oils.

KEY-WORDS: Model blends - Rice bran oil - Sunflower oil - Thermal behavior.

1. INTRODUCTION

Deep fat frying is a complex process involving a number of factors such as the actual process itself, the frying fat and the nature of the food to be fried (Varela et al., 1988). It involves a unique food processing operation, wherein the frying medium becomes a constituent of the fried food. Blended oils are gaining popularity worldwide due to advantages they offer such as improved thermal stability, oxidative stability, nutritional benefits (Sharma et al., 1996a ; Frankel and Huang, 1994) and an ability to tailor the desired properties. Most importantly, they are cheaper alternatives or substitutes to pure vegetable oils. A comparison of the absorption of oil by chick pea (*Cicer arietium*) dal fried in groundnut, cottonseed, rapeseed and their blends has shown that the absorption of cottonseed oil is minimal. Lower peroxide values were reported in stored food items which were fried in rapeseed-cottonseed blends compared to those fried in groundnut-cottonseed and groundnut-rapeseed oil blends (Mehta et al., 1986). The blends of 50% palm kernel olein with 50% coconut oil were suitable, if crude oils with a coconut flavor were desired (Lee and Timms, 1988). A blend of marine and vegetable oils (1:3) has been used for frying, baking or for the preparation of margarines without the development of a fishy odor (Freeman et al., 1988). The pattern of oil uptake constituents during the frying of dehydrated potato chips has been reported (Sharma et al., 1996 b). Premavalli et al., (1998) investigated the storage and thermal stabilities of refined cottonseed oil-mustard seed oil blends (80:20). Comparative studies on physical properties of vegetables oils and their blends after frying indicated a minimization in peroxide value using blended oils (Susheelamma et al., 2002). Commercialization has been started in this respect and a few oil blends have already been permitted. This trend is likely to increase in the near future. Therefore, thorough investigations aimed at studying the frying behavior of various types of blended oils are the most urgently needed. The present study was aimed at exploring the frying behavior of blended oils prepared from different proportions of sunflower oil and rice bran oil.

2. MATERIALS AND METHODS

Refined rice bran oil and sunflower oils were obtained from a reliable source. Dried potato chips were purchased from a local market. Samples of pure rice bran oil, sunflower oil, and their blends were prepared in the ratio 80:20, 70:30, 60:40, 50:50, 40:60, 30:70 and 20:80 (by volume). All the oil samples were kept at room temperature (25±2 °C) in amber colored bottles (capacity 750 ml).

2.1. Deep fat frying of potato chips

The frying of a known weight (50 g) of potato chips was carried out by drawing 500 ml of oil sample from pure as well as blended oils separately in a frying pan (diameter 17 cm, depth 5 cm) at a deep fat frying temperature of 200°C for 9 sec. Deep fat frying time and temperatures were decided based on preliminary experiments carried out in the laboratory. Another frying operation was carried out in 500 ml of oil under the same frying conditions. After frying, the oil samples from pure as well as blended oils were cooled to room temperature and stored separately in PET bottles for three days for further frying. After 3 days, 80 ml of oil sample were taken from pure and blended oils for the physico-chemical parameters and lipid profile. After every frying cycle, the volume of all oil samples was again made up to 500 ml by adding oil from another frying operation carried out under similar conditions. The same frying processes were repeated six times with each and every oil sample after successive storage of oils for three days and withdrawing 80 ml oil sample. The total time for an experiment was 18 days.

2.2. Analysis

After each frying cycle, the oil samples were analyzed for acid value, peroxide value, iodine value, refractive index and specific gravity (AOAC 1970). Color value was measured by using Lovibond tintometer (AOAC 1970). Fatty acids of triglycerides were analyzed by preparing methyl esters according to a conventional procedure consisting of saponification followed by acidification and finally methylation using diazomethane (Bandyopadhyay and Gholap 1973). Gas chromatographic (GC) analysis of fatty acid methyl esters was carried out using a NUCON SERIES 5700 of data station 0-2.5 mV range and < 1.5s response rate. A 2m x 2 mm stainless steel 10% Silar 7C column packed with 60-120 mesh Gas Chrom Q was used. The injector and detector temperatures were maintained at 240°C. The column temperature was set at 160°C for 5 min and then ramped at a rate of 5 °C per min to a final temperature of 220°C and kept there for 20 min. The total time for analysis was 37 min. Fatty acids were tentatively identified by comparison with retention times of authentic reference samples.

2.3. Statistical analysis

Analysis of variance (ANOVA) was used to calculate the F-ratio and critical difference (CD) of experimental values, to statistically predict the significance or insignificance.

3. RESULTS AND DISCUSSION

In the present work dehydrated potato chips were fried in rice bran oil (RBO), sunflower oil (SFO) and their model blends in different proportions. The refractive index and specific gravity at room temperature (25±2 °C) for pure rice bran oil and sunflower oil were 1.4650 and 1.4640 and 0.9180 and 0.9135 respectively before frying. Their model blends, prepared in the different ratio as given in the respective Tables had a refractive index and specific gravity in the range of 1.4650 to 1.4642 and 0.9170 to 0.9134 respectively. No significant change ($P<0.05$) was observed in the refractive index and specific gravity of pure rice bran oil, sunflower oil or their model blends during repeated deep fat frying cycles.

Table 1 indicates the acid value of pure rice bran oil, sunflower oil and their model blends in different

Table 1
Acid value of pure rice bran oil and its blend with sunflower oil

Oils	Initially	After 1st frying	After 2nd frying	After 3rd frying	After 4th frying	After 5th frying	After 6th frying	F Ratio	CD (5%)
RBO	0.163	0.170	0.188	0.196	0.198	0.202	0.210	5.000	0.020
80%RBO+20%SFO	0.130	0.154	0.151	0.152	0.172	0.182	0.202	8.850	0.017
70%RBO+30%SFO	0.120	0.132	0.148	0.150	0.155	0.160	0.181	8.830	0.016
60%RBO+40%SFO	0.097	0.110	0.124	0.132	0.139	0.160	0.166	8.960	0.017
50%RBO+50%SFO	0.095	0.100	0.113	0.120	0.119	0.151	0.159	8.750	0.017
40%RBO+60%SFO	0.070	0.090	0.094	0.097	0.100	0.110	0.114	8.990	0.157
30%RBO+70%SFO	0.060	0.072	0.079	0.083	0.086	0.099	0.091	2.960	0.214
20%RBO+80%SFO	0.050	0.070	0.075	0.071	0.072	0.083	0.078	8.390	0.009
SFO	0.022	0.025	0.028	0.041	0.042	0.043	0.059	8.960	0.009

- Results are average of three individual experiments
RBO- Rice bran oil; SFO- sunflower oil

proportions during repeated deep fat frying cycles. Pure rice bran oil and sunflower oil were found to contain an acid value of 0.163 and 0.022 respectively. It was observed that the acid value increased after the deep fat frying cycles but no significant difference ($P<0.05$) was observed in the acid values of the oil samples between consecutive frying cycles. No sample can be declared inferior in terms of thermal stability on the basis of these parameters even after the sixth frying cycle because all the oil samples had acid values lower than 0.5 (PFA, 1954).

Pure rice bran oil and sunflower oil were found to contain iodine values of 95.40 and 113.4 respectively (Table 2). Their model blends had iodine values in the range of 101.4-108.9 before frying. The iodine values of pure oils and their model blends were gradually decreased during repeated deep fat frying cycles. In pure rice bran oil and sunflower oil iodine values decreased from 95.40-89.09 and 113.4-102.8 for the control sample and the sample taken after the sixth repeated frying cycle. The decrease in iodine value may be attributed to the oxidative and thermal degradation reactions during the deep fat frying process. The decrease in iodine number was more pronounced in the case of pure sunflower oil as compare to the pure rice bran oil. The model blends constituting 80%RBO + 20%SFO and 70%RBO + 30%SFO showed a lower decrease in the iodine number as compare to other blends except 60%RBO + 40%SFO indicating fewer changes under deep fat frying conditions.

Data shown in Table 3 indicate the peroxide values of pure rice bran oil, sunflower oil and their model blends during repeated deep fat frying cycles. Pure rice bran oil and sunflower oil were found to increase their peroxide values from 0.38 to 3.99 and 0.59 to 4.88 for the control sample and sample taken after the sixth cycle of frying respectively. The rest of the oil blends had peroxide values in the range of 0.45 to 0.57 before frying. Sunflower oil, as a frying medium showed a significant increase in peroxide value during the deep fat frying process. The initial peroxide values of pure rice bran oil, sunflower oil and their model blends were found to be significantly ($P<0.05$)

Table 2
Iodine value of pure rice bran oil and its blend with sunflower oil

Oils	Initially	After 1st frying	After 2nd frying	After 3rd frying	After 4th frying	After 5th frying	After 6th frying	F Ratio	CD (5%)
RBO	95.40	95.0	94.2	93.5	91.5	90.89	89.09	5.80	2.0321
80%RBO+20%SFO	100.1	98.0	95.9	95.2	94.7	94.2	93.8	8.90	4.6581
70%RBO+30%SFO	101.5	100.0	99.6	96.9	95.9	95.5	94.9	7.57	2.4152
60%RBO+40%SFO	102.9	101.1	100.4	99.9	98.4	97.8	97.1	7.71	2.7618
50%RBO+50%SFO	104.7	102.3	102.2	101.5	99.8	98.2	97.05	4.66	2.3377
40%RBO+60%SFO	105.6	103.7	102.5	102.2	101.2	100.6	99.4	5.11	1.6407
30%RBO+70%SFO	106.8	105.5	103.8	103.3	102.7	101.9	99.1	2.42	2.4924
20%RBO+80%SFO	108.9	107.8	105.8	103.8	102.5	102.1	100.9	8.60	2.0234
SFO	113.4	108.5	107.8	107.5	106.4	104.9	102.8	7.43	2.9290

- Results are average of three individual experiments
RBO- Rice bran oil; SFO- sunflower oil

Table 3
Peroxide value of pure rice bran oil and its blend with sunflower oil

Oils	Initially	After 1st frying	After 2nd frying	After 3rd frying	After 4th frying	After 5th frying	After 6th frying	F Ratio	CD (5%)
RBO	0.38	1.08	1.59	2.14	3.08	3.78	3.99	8.89	0.9606
80%RBO+20%SFO	0.45	1.26	2.17	2.42	3.35	3.74	3.85	8.82	0.8659
70%RBO+30%SFO	0.48	1.55	1.84	2.51	2.77	3.80	3.91	8.71	0.8774
60%RBO+40%SFO	0.54	1.53	2.35	2.59	2.88	3.77	3.89	7.24	0.8882
50%RBO+50%SFO	0.54	1.58	2.67	2.73	2.91	3.05	3.92	8.24	0.8064
40%RBO+60%SFO	0.55	1.56	2.69	2.78	3.35	3.52	3.99	7.57	0.9113
30%RBO+70%SFO	0.56	1.73	2.09	2.75	3.26	3.78	4.09	7.73	0.9287
20%RBO+80%SFO	0.57	1.69	2.95	3.07	3.67	3.91	4.36	7.30	1.0274
SFO	0.59	1.69	3.69	3.80	3.94	4.27	4.88	8.54	1.0949

- Results are average of three individual experiments
RBO- Rice bran oil; SFO- sunflower oil

different after the first deep fat frying process and throughout the six repeated frying cycles.

Pure refined sunflower oil was very light in color (1.0 units) as compared to pure refined rice bran oil (15.5 units). The model blends had color values in the range of 5.0 to 12.0 before frying. The color value index of pure oils and their model blends increased gradually during repeated deep fat frying cycles (Table 4). Food when fried at such a high temperature can introduce various components into the oil such as carbohydrates, phosphates, sulphur compounds, trace metals etc. The formation of nonvolatile decomposition products is due primarily to thermal oxidation and polymerization of the unsaturated fatty acids in fat. Many of these compounds contribute to color formation along with other changes (Whitfield, 1992). The color value of pure sunflower oil and rice bran oil increased to 5.6 and 28.5 after the sixth frying cycle compared to the control value of 1.0 and 15.5 (before frying) respectively. As the ratio of pure rice bran oil decreases, the color value decreases which was expected due to large differences in the color value of the control samples. A model blend constituting 20%RBO + 80%SFO was found to show the least change in color value among all the blends.

Table 5 indicates changes in myristic, palmitic and stearic acid in pure rice bran oil, sunflower oil

Table 4
Color value of pure rice bran oil and its blend with sunflower oil

Oils	Initially	After 1st frying	After 2nd frying	After 3rd frying	After 4th frying	After 5th frying	After 6th frying	F Ratio	CD (5%)
RBO	15.5	20	20.0	20.8	21.0	24.9	28.5	8.99	3.2190
80%RBO+20%SFO	12.0	15	18.5	19.2	19.5	22.5	25.0	8.99	3.0184
70%RBO+30%SFO	10.5	14	17.5	17.8	19.0	20.0	23.4	9.00	2.8983
60%RBO+40%SFO	9.0	12.5	15.0	16.0	16.5	19.5	21.8	8.89	2.9624
50%RBO+50%SFO	8.0	10.5	13.5	14.0	14.5	18.7	20.6	4.00	4.3274
40%RBO+60%SFO	7.6	10.0	11.5	11.9	12.7	15.0	17.2	8.98	2.1904
30%RBO+70%SFO	6.5	8.5	8.7	9.0	9.2	12.9	14.0	9.00	1.8370
20%RBO+80%SFO	5.0	6.0	6.5	6.9	7.5	8.9	9.5	8.88	1.1095
SFO	1.0	1.5	2.0	2.5	2.6	4.5	5.6	8.61	1.1744

- Results are average of three individual experiments
RBO- Rice bran oil; SFO- sunflower oil

Table 5
Major saturated fatty acids composition of pure rice bran oil and its blend with sunflower oil

% Fatty acid composition	Oils	Initially	After 1st frying	After 2nd frying	After 3rd frying	After 4th frying	After 5th frying	After 6th frying
C_{14}	RBO	0.23	0.23	0.25	0.28	0.29	0.30	0.30
	80%RBO+20%SFO	0.22	0.24	0.24	0.29	0.29	0.29	0.30
	70%RBO+30%SFO	0.18	0.18	0.18	0.19	0.19	0.19	0.21
	60%RBO+40%SFO	0.16	0.16	0.18	0.19	0.21	0.21	0.22
	50%RBO+50%SFO	0.11	0.13	0.14	0.19	0.19	0.23	0.23
	40%RBO+60%SFO	0.10	0.10	0.11	0.13	0.13	0.15	0.17
	30%RBO+70%SFO	0.07	0.10	0.11	0.14	0.14	0.15	0.16
	20%RBO+80%SFO	0.03	0.08	0.09	0.11	0.12	0.12	0.14
	SFO	0.02	0.06	0.10	0.13	0.13	0.16	0.17
C_{16}	RBO	18.09	18.12	18.30	18.31	18.34	18.34	18.44
	80%RBO+20%SFO	14.85	15.39	15.46	15.58	15.63	15.68	15.74
	70%RBO+30%SFO	14.32	14.57	14.96	14.99	15.13	15.15	15.20
	60%RBO+40%SFO	12.42	12.44	12.49	12.75	12.88	12.99	13.16
	50%RBO+50%SFO	10.49	10.50	10.82	11.60	12.01	12.06	12.40
	40%RBO+60%SFO	9.24	9.95	9.99	10.40	10.78	10.88	10.95
	30%RBO+70%SFO	8.93	8.40	9.33	9.37	9.40	10.72	10.91
	20%RBO+80%SFO	8.08	8.34	8.39	8.55	9.02	9.39	9.42
	SFO	5.45	5.65	5.67	5.80	5.83	5.90	6.91
$C_{18:0}$	RBO	3.22	3.34	3.45	3.50	3.51	3.58	3.94
	80%RBO+20%SFO	3.25	3.34	3.34	3.40	3.45	3.50	3.58
	70%RBO+30%SFO	3.33	3.38	3.45	3.54	3.56	3.58	3.76
	60%RBO+40%SFO	3.57	3.62	3.63	3.65	3.66	3.71	3.74
	50%RBO+50%SFO	3.69	3.70	3.72	3.78	3.83	3.88	4.00
	40%RBO+60%SFO	3.89	4.36	4.39	4.43	4.53	4.56	4.62
	30%RBO+70%SFO	4.11	4.30	4.32	4.33	4.43	4.45	4.66
	20%RBO+80%SFO	4.20	4.23	4.32	4.39	4.43	4.56	4.65
	SFO	4.45	4.49	4.53	4.63	4.65	4.67	4.78

RBO- Rice bran oil; SFO- sunflower oil

and their model blends. Pure sunflower oil and rice bran oil contained myristic, palmitic and stearic acid in the proportions of 0.02% and 0.23%, 5.45% and 18.09% and 4.45% and 3.22% respectively. Compositions of myristic, palmitic and stearic acid in pure rice bran and sunflower oil have been reported to be 1.0% and 0.5%, 18-20% and 3-10%, and 2.5-3.5% and 1-10% respectively (Orthoefer and Smith, 1996). The respective model blends, as given in the Table had myristic, palmitic and stearic acid compositions in the range of 0.03 to 0.22%, 8.08 to 14.85% and 3.25% to 4.20% before frying. Data in Table 5 shows the increasing trend of saturated fatty acids during the repeated deep fat frying. Blended oil, constituting 60%RBO + 40% SFO showed the smallest changes in palmitic and stearic acid compositions from 12.42 to 13.16% and 3.57 to 3.74% as compared to other model blends. Similar trends were also observed in myristic acid composition except the model blends 70% RBO +30% SFO.

Table 6 indicates the changes in oleic, linoleic and linolenic acids in pure rice bran oil, sunflower oil and their blends. Pure sunflower oil and rice bran oil had oleic, linoleic and linolenic acid in the proportions of 51.61% and 45.02%, 37.47% and 30.99%, and 0.41% and 0.76% respectively. Compositions of oleic, linoleic and linolenic acid in pure rice bran and sunflower oil have been reported to be 40-42% and 14-65%, 32-35% and 20-75% and 1-1.5% and 0.7% respectively (Orthoefer and Smith, 1996). The model blends had oleic, linoleic and linolenic acid compositions in the range of 47.51 to 50.24%, 31.25 to 35.81% and 0.43 to 0.65 % respectively before frying. The data indicates that the amount of unsaturated fatty acid decreased gradually during repeated deep fat frying cycles. This may be due to oxidative and thermal degradation reactions during repeated deep fat frying cycles in the unsaturated fatty acid constituents of triacylglycerols (Garrido-Polonio et al., 1994). Comparable changes were observed in all the blended oils during repeated frying as compared to the pure oils. Blended oils consisting of 60%RBO + 40%SFO were found to have smaller differences in their linoleic acid composition, from 33.68 to 32.47% for the control sample and the sample after the sixth frying cycle, indicating smaller changes in the linoleic acid composition during deep fat frying compared to the other blends (Table 6).

Pure rice bran oil and sunflower oil showed good thermal stability during the repeated deep fat frying cycles. Although all the blended oils used in the

Table 6
Major unsaturated fatty acids composition of pure rice bran oil and its blend with sunflower oil

% Fatty acid composition	Oils	Initially	After 1st frying	After 2nd frying	After 3rd frying	After 4th frying	After 5th frying	After 6th frying
$C_{18:1}$	RBO	45.02	44.92	44.37	44.54	44.55	44.03	43.29
	80%RBO+20%SFO	47.51	46.66	46.60	46.40	46.28	45.95	45.87
	70%RBO+30%SFO	48.49	47.94	47.08	46.42	46.22	46.09	45.99
	60%RBO+40%SFO	48.75	47.19	46.95	46.60	46.51	46.12	46.10
	50%RBO+50%SFO	49.22	48.02	47.84	47.67	47.59	47.08	46.97
	40%RBO+60%SFO	50.37	49.15	48.73	47.58	47.38	47.27	47.15
	30%RBO+70%SFO	50.32	50.24	49.53	49.08	47.95	47.56	46.40
	20%RBO+80%SFO	50.24	49.89	49.84	49.39	48.32	48.25	48.09
	SFO	51.61	51.54	51.61	50.60	50.11	50.10	50.04
$C_{18:2}$	RBO	30.99	30.97	30.88	30.62	30.58	30.54	30.28
	80%RBO+20%SFO	31.25	30.85	30.51	30.36	30.14	30.09	30.02
	70%RBO+30%SFO	31.28	30.33	30.26	30.17	30.07	30.06	29.88
	60%RBO+40%SFO	33.68	33.63	33.40	32.92	32.76	32.49	32.47
	50%RBO+50%SFO	35.21	34.84	34.59	34.33	33.51	33.35	33.05
	40%RBO+60%SFO	35.24	35.16	35.07	34.69	34.13	34.06	34.01
	30%RBO+70%SFO	35.39	35.28	34.55	34.44	34.25	33.72	33.64
	20%RBO+80%SFO	35.81	35.09	34.86	34.58	34.16	33.96	33.58
	SFO	37.47	37.34	37.22	37.20	37.10	36.99	36.26
$C_{18:3}$	RBO	0.76	0.76	0.75	0.63	0.61	0.60	0.59
	80%RBO+20%SFO	0.65	0.64	0.63	0.59	0.53	0.52	0.50
	70%RBO+30%SFO	0.57	0.57	0.55	0.54	0.53	0.51	0.50
	60%RBO+40%SFO	0.47	0.44	0.42	0.41	0.39	0.34	0.34
	50%RBO+50%SFO	0.46	0.44	0.41	0.40	0.38	0.36	0.35
	40%RBO+60%SFO	0.45	0.45	0.40	0.39	0.38	0.34	0.34
	30%RBO+70%SFO	0.45	0.44	0.39	0.37	0.37	0.33	0.32
	20%RBO+80%SFO	0.43	0.42	0.41	0.39	0.36	0.33	0.32
	SFO	0.41	0.39	0.37	0.36	0.35	0.33	0.31

RBO- Rice bran oil; SFO- sunflower oil

study also showed good thermal stability during repeated deep fat frying cycles, model blends consisting of 60%RBO + 40% SFO did not show any significant change in specific gravity, refractive index or acid value and small changes in iodine value, palmitic, stearic, and linoleic acid during repeated deep fat frying cycles therefore indicating better suitability for repeated deep fat frying than the remaining blended oils.

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