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QUALITY IMPROVEMENT OF USED FRIED RAPESEED OIL BY TREATMENT WITH ACTIVATED CHARCOAL AND MAGNESIUM OXIDE

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Rapeseed oil was used for frying of potato fillets (French fries) for 4 consecutive days at a rate of 20 minutes per day. The quality constants such as peroxide value (POV), anisidine value (AV), free fatty acid polar compounds (FFA%) and colour index (as OD at 420 nm) were determined before and after frying. The results showed an increasing pattern in the values of quality parameters. The POV increased from 4.42 to 17.00 meq kg^{-1}, AV from 8.37 to 65.60, FFA from 0.02 to 1.90% and colour (absorbance at 420 nm) from 0.16 to 2.20. Fried rapeseed oil was mixed separately with 3 levels of MgO (2, 4 and 6% w/w) and activated charcoal (2, 6 and 10% w/w). For all the treatments the average % improvement of quality indices was statistically analysed. Increasing levels of both activated carbon and MgO significantly affected (P<0.05) the different quality parameters tested so far.

Keywords: rapeseed oil, frying, activated charcoal, magnesium oxide

Deep fat frying is a common food processing method used worldwide for cooking many foods. Economic considerations and the need to produce fried foods of uniformly desirable quality have stimulated interest in extending the useful life of frying fats. Oxidation, hydrolysis and thermal decomposition of frying oil take place resulting in degradation of oil (CHANG et al., 1978). The degradation products include both volatile and non-volatile compounds (AHMAD et al., 1993; AKHTAR et al., 1985). Although most of the volatiles are lost through steam distillation during the frying process, some remain in the oil and may be consumed with the fried foods and nonvolatile decomposition products are produced primarily by thermal oxidation and polymerization of unsaturated fatty acids (MCNEILL et al., 1986). They also reported that polar compounds are of particular concerns because they accumulate in the frying oil where they promote further degradation and may be absorbed by the fried food and enter the diet of the consumers. LUMLEY (1988) observed that fats rich in unsaturated fatty acids yield more polymers than those having low unsaturated fatty acids. AHMAD (1999) reported that huge amount of oils and fat are used for deep fat frying and the deep fat fried foods are major items of human diet. It is absolutely essential to ascertain the extent to which frying oil can be

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used. One commonly used method of maintaining oil quality is to add fresh oil periodically. Another procedure involves filtering the oil on a daily or continuous basis. Filtering is capable of extending the cooking life of frying oils. Food particles, if not removed before next utilization, may burn and develop undesirable flavours and increase the rate of oil deterioration. The adsorbent materials improve oil quality by reducing the level of free fatty acids and colour compound (MANCINI-FILHO et al., 1986). Considerably less work has been published on procedure to clean or purify fried oils in Pakistan. The efficacy of activated carbon and magnesium oxide to improve the quality of used frying oils was investigated in this study.

1. Materials and methods

The sample of rapeseed was obtained from Mutation Breeding Section of NIFA, cleaned, and the oil was extracted mechanically by cold pressing and filtered through filter paper. One kg of potato fillets were fried in 2 l of oil for 20 min in conventional aluminum frying pane at 180 °C for 4 consecutive days. After each frying, oil was allowed to cool to room temperature for 18 h and was again used for next frying. Samples of oil from each test frying were taken after each cooling cycle and analysed for POV, iodine value (IV), and FFA according to standard procedures (A.O.C.S., 1972). Anisidine value was determined with the method described by PORIM (1993). The colour of oil (50% v/v solution of oil solution in iso-octane) was measured as optical density at 420 nm using Shimadzu UV-Vis spectrophotometer 160 by the method described by MANCINI-FILHO and co-workers (1986). The percentages of polar compounds were determined as described by SEBEDIO and co-workers (1987). The fatty acid composition of oil was determined by employing the trans-esterification method using sodium methoxide as reported by SHEHATA and co-workers (1970). Aliquots of 100 g of untreated used oil were taken and treated with three levels (2, 6, 10% w/w) of activated carbon and MgO (2, 4, 6% w/w) separately in a 250 ml bottle and agitated for 20 minutes in a shaking water bath. The oil samples were a centrifuged at 3,000 r.p.m. for 15 min and filtered through 2 layers of Whatman filter paper No 1 under vacuum. The filtered oil was stored for analysis. The improvement in quality of oil was determined by standard formula:

$$\text{Improvement } \% = \frac{(\text{untreated used oil} - \text{treated used oil})}{\text{untreated used oil} - \text{unused fresh oil}} \times 100 ,$$

Potato chips were prepared in fresh as well as in treated oils and subjected to trained panelists for evaluation of the products for colour, odour and crispiness in individual booths. Statistical analysis of the data on % improvement were performed by analysis of variance, determining the co-efficient of variation (CV) which is the percentage of standard deviation to the mean (LITTLE & HILLS, 1972).

2. Results and discussions

Physical and chemical changes in the rapseed oil used for frying French fries over a four day period are shown in Fig. 1. The results illustrated progressive deterioration of the oil. Control oil (day 0) without any frying showed the lowest values in POV, FFA, AV and colour. The rate of oxidation as measured by POV increased from 4.42 to 17.00 meq kg^{-1} and FFA from 0.02 to 1.90% with the successive increase in frying time. Anisidine values measure the secondary breakdown products of peroxides and hydro-peroxides, which are formed at rapid rate during frying (WERMAN & NEEM, 1986). The results regarding the influence of frying time on colour of oil measured as OD at 420 nm showed increased absorbance with increasing frying time from 0.16 to 2.20. The increase in colour during frying of oils has also been reported by AHMAD and co-workers (1996). They further stated that measurement of oil colour could not be used to monitor oil quality due to the possibility of interference of food components with oil during frying. Iodine value showed a decreasing trend with increasing frying time, primarily due to decrease in unsaturation during frying process resulting in the increase of viscosity. The IV was 111.7 g/100 g in control sample, which decreased to 101.6 g/100 g after the 4th day of frying. Similar trend has also been reported in sunflower, soybean, corn and crude rapeseed oils (CHU & LUO, 1994). The anisidine value in this study repeatedly increased from 8.37 to 65.60. Some workers (AHMAD, 1999) showed that anisidine value, polymer contents, foam height and other quality parameters generally increased as long as frying period was advanced. WAHALE (1997) reported that poly-unsaturated oils have reduced stability at elevated temperatures and their peroxide value gradually increased. Initially the polar compounds' concentration was 5.6% which increased to 9.0% after day one of frying, and it successively increased to 17% on day 4 of frying. Treatment of the oil with activated carbon and MgO was effective in reducing the FFA, POV, AV, polar compounds and photometric colour. The results were expressed as % improvement and subjected to the analysis of variance procedure. Each treatment levels were replicated thrice and the average % improvement was calculated (Tables 1 and 2). Among the two treatments the increasing levels of both activated carbon and MgO significantly ($P<0.05$) affected FFA. The highest treatment levels of carbon (10%) and MgO (6%) resulted in 56.3% and 64.3% improvement, respectively in case of FFA, indicating that magnesium oxide is more effective than activated carbon. Conversely, activated carbon was effective in discoloration (66.8%) of the used oil due to the adsorptive characteristic of activated carbon, which removes impurities by occlusion. To assess the effectiveness of the adsorbents on reducing the levels of peroxide and anisidine values, the overall % improvement (mean of 9 values) was calculated. The MgO treated samples showed slightly better improvement for POV (35.9%) and anisidine value (13.3%), while in case of charcoal treated samples the improvement was 26.6 and 10.3%, respectively. Different levels of treatments of activated carbon and MgO were statistically significant in improvement of oil quality by reducing POV and AV. On refurbishing with MgO (6%) and charcoal (10%), the polar compound was reduced by 22.5% and 29.1%, respectively. Similar results were reported by some workers (MCNEILL et al., 1986). Some workers (MANCINI-FILHO et al., 1986) reported that commercially used shortenings treated with bleaching clay, charcoal, magnesium oxide and celite and their mixtures, effectively reduced the quality indices i.e. dielectric constant, free fatty acid, colour and total polar compounds in the fried oil. They further stated that a lower level of adsorbents and longer contact times may increase the yield values without diminishing the degradation products, while minimizing oil losses. Results regarding selected fatty acid composition are presented in Table 3. The concentration of 3 important unsaturated fatty acids, linolenic, linoleic and oleic acid decreased by 26.31%, 32.23% and 36.90%, respectively, with 4 days frying. Regarding the quality improvement in fatty acids by treating with MgO and charcoal, 5–15% increase in the levels of linolenic, linoleic and oleic acid was observed. Similar results were observed by MCNEILL and co-workers (1986), while working on quality improvement of used canola oil by treatment with activated carbon and silica. Sensorically all fresh (0 day) chips had high characteristic odour/flavour. After day 4 of frying chips were more intense in buttery odour/flavour. As the frying time increased the bitter flavour and aftertaste increased in chips. For day-0 and day-4 chips, there were no differences in sensory hardness or crispiness and colour of the chips. The chips prepared in refurbished oil were rated as being different compared to fresh oil with regard to flavour, crispiness and colour.

Table 1. Effect of activated charcoal concentrations on % improvement of fried rapeseed oil

Concentration	Replication	FFA	POV	AV	Colour
2%	1	45.9	22.6	10.0	49.5
	2	46.3	23.5	8.7	48.3
	3	48.9	21.7	9.1	46.9
	Mean	47.03[c]	22.6[b]	9.26[b]	48.23[b]
6%	1	51.8	27.1	9.3	50.5
	2	54.3	28.1	10.1	52.1
	3	55.5	27.9	9.5	55.3
	Mean	53.8[b]	27.7[a]	9.63[b]	52.63[b]
10%	1	56.2	29.8	11.5	60.3
	2	56.2	28.7	12.7	57.9
	3	56.6	30.5	12.5	63.8
	Mean	56.33[a]	29.67[a]	12.23[a]	60.67[a]
Overall mean		52.41	26.65	10.37	53.84
CV		1.92	3.61	6.78	4.35
LSD		2.28	2.18	1.59	5.35

Figures sharing the common letters are not significantly different ($P<0.05$)

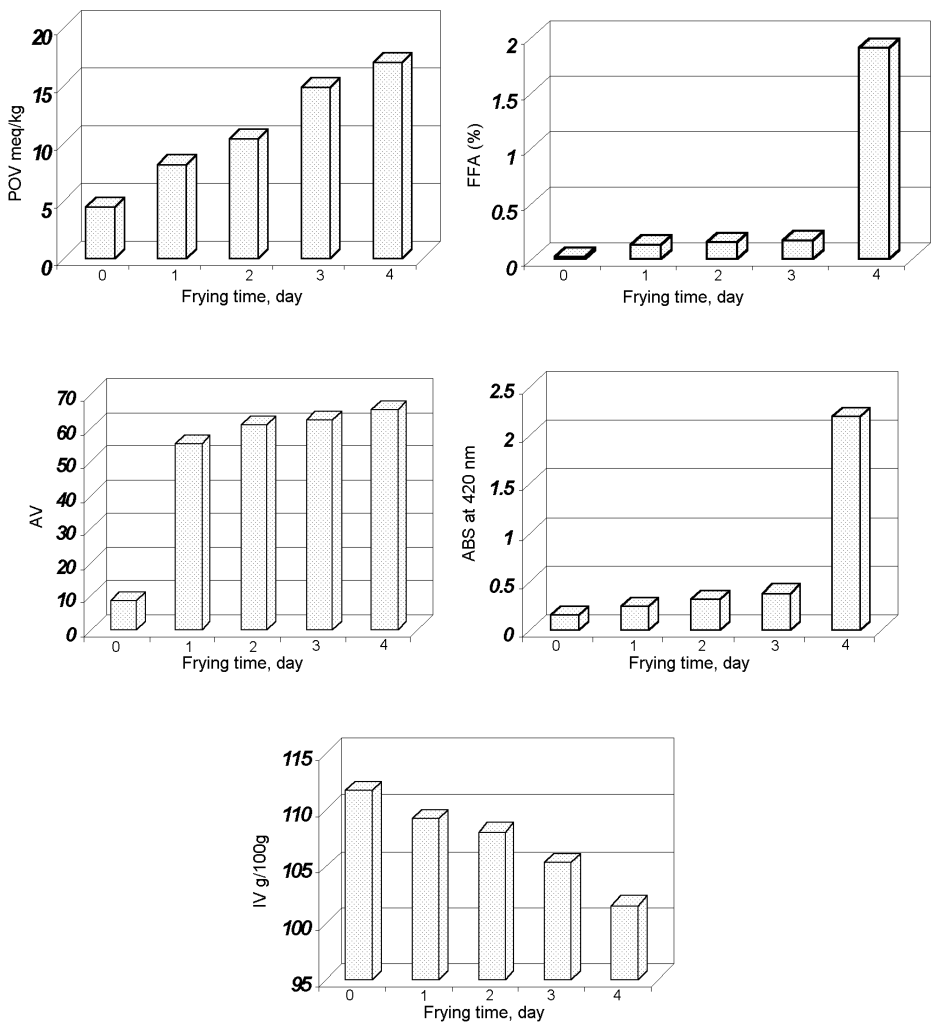

Fig. 1. Effect of successive frying on selected quality parameters of rapeseed oil. Peroxid value (POV); free fatty acids (FFA) anisidine value (AV); colour (ABS at 420 nm) and iodine value (IV). Frying was carried out on four successive days

Table 2. Effect of magnesium oxide concentrations on % improvement of fried rapeseed oil

Concentration	Replication	FFA	POV	AV	Colour
2%	1	51.8	32.2	10.7	39.4
	2	53.5	32.5	11.5	42.4
	3	55.5	31.7	9.1	40.5
	Mean	53.6[c]	32.13[b]	10.43[b]	40.77[a]
4%	1	57.9	37.2	12.7	37.8
	2	56.5	35.2	12.5	40.7
	3	58.2	37.6	13.4	43.1
	Mean	57.53[b]	37.67[a]	12.87[b]	40.53[a]
6%	1	62.4	39.4	15.1	43.7
	2	64.5	40.6	16.9	46.3
	3	66.1	37.4	18.5	45.5
	Mean	64.3[a]	39.13[a]	15.83[a]	45.17[a]
Overall mean		58.48	35.97	13.78	45.47
CV		1.92	3.94	10.49	22.46
LSD		2.54	3.21	3.18	23.16

Figures sharing the common letters are not significantly different ($P<0.05$)

Table 3. Effect of frying and adsorbents on selected fatty acid composition (%) of rapeseed oil

Fatty acids		Fresh	Fried	MgO treated	Charcoal treated
Palmitic	16:0	3.7	2.8	3.1	3.2
Stearic	18:0	1.2	0.9	1.0	1.1
Oleic	18:1	15.7	9.9	10.9	11.2
Linoleic	18:2	15.2	10.3	11.7	11.9
Linolenic	18:3	9.5	7.0	7.4	7.5

Percentages based on 3 determinations

3. Conclusions

From the results of this study it was concluded that deep fat frying increased the peroxide value, free fatty acid, colour and decreased the iodine value. Profound increase in anisidine value and decrease in iodine value are of special significance regarding the deterioration of oil. The quality of fried oil could be improved by the use of activated charcoal powder and MgO and can be reused for frying. Regarding the treatment, magnesium oxide was found better in improving the quality of oil than activated charcoal.

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