RESULTS AND DISCUSSION

CHAPTER 5

RESULTS AND DISCUSSION

The broad objective of the present study was to assess the frequency of fried food intake by Gujarati housewives and its association with their morbidity profile, assess the sensory qualities of french fries and bhajias fried in cottonseed and groundnut oil at intermittent intervals, determine the intermittent frying stability of cottonseed and groundnut oil, and also to assess the food safety and frying practices prevailing at the Government run food outlet at Vadodara railway station.

This chapter presents the results of the respective phases of the study followed by discussion of respective phase under the following heads:

5.1 Phase I - Fried food intake, knowledge on fats and oils and frying practices of the Gujarati housewives of urban Vadodara and its association with the prevalence of non-communicable diseases (NCDs).

5.2 Phase II - Sensory qualities of french fries and bhajias fried in cottonseed oil (CSO) and groundnut oil (GNO) during intermittent frying.

5.3 Phase III - Chemical changes due to thermal degradation of intermittently deep fried cottonseed oil (CSO) and groundnut oil (GNO) as a result of french fries and bhajias frying.

5.4 Phase IV - Case study on prevailing food safety and frying practices in Jan aahar- a Government run food outlet at Vadodara railway station.

5.5 Phase V - Development of Nutrition Health Education (NHE) material in two languages on intake of edible oil, types, and on choices of oils for healthy living and problems during frying of edible oil and its storage.

PHASE I

5.1: FRIED FOOD INTAKE, KNOWLEDGE ON FATS AND OILS AND FRYING PRACTICES OF THE GUJARATI HOUSEWIVES OF URBAN VADODARA AND ITS ASSOCIATION WITH THE PREVALENCE OF NON-COMMUNICABLE DISEASES (NCDs)

Oil consumption is recognized as one of the major factors playing a significant adverse role in health hazard in terms of heart disease, diabetes, hypertension and cancers. In light of the multifaceted views and complex relationship between oil, fried food consumption and heath, the objective of this phase was to assess the fried food intake, knowledge on oils and fats and frying practices of Gujarati housewives of urban Vadodara and its association with the prevalence of NCDs.

In this phase of the study, 120 Gujarati housewives were surveyed for their practices on type of oil used for cooking; the survey was specifically aimed at collecting information on the consumption pattern of popularly consumed deep fried, shallow fried and sweets prepared at home and purchased from market of Vadodara and its association with prevalence of NCDs. The association between the knowledge level on *trans* fats and the education level of the subjects was also determined.

The results of this phase are presented under the following heads:

5.1.1: General information of Gujarati house wives

5.1.2: Anthropometric measurements, prevalence of non-communicable diseases (NCDs) and gastrointestinal (GI) problems

5.1.3: Food habits; preferred cooking method for a meal and its frequency

5.1.4: Consumption pattern of fried foods prepared at home and its association with prevalence of NCDs and GI problems

5.1.5: Consumption pattern of fried foods purchased from market and its association with prevalence of NCDs and GI problems

5.1.6: Eating out frequency; preferred cooking methods and foods preferred during long distance travelling

5.1.7: Oil consumption pattern, its use and association with prevalence of NCDs and GI problems

5.1.8: Use of leftover fried oil, containers used for oil storage and practices of storing fried oil

5.1.9: Knowledge on refrying and filtration of fried oil before storage

5.1.10: Changes observed in fresh oil upon frying and storage of fresh oil

5.1.11: Knowledge on oil blends and trans fats

5.1.1: General information of Gujarati housewives

As seen in Table 5.1.1 the education level of the subjects revealed that most women (57.5%) were graduate. Under activity pattern, exercise pattern of subjects revealed that almost 50% housewives exercised regularly in the form of brisk walking, yoga and jogging. Further, maximum number (62.5%) of subjects share household work with maid. According to Kuppuswamy (2007) classification family monthly income of 71.6% subjects was up to ₹10,000 and 28.3% families had more than ₹30,000 as their monthly income.

Table 5.1.1: General information of Gujarati housewives

General information	No (%) (n=120)
Education:	
Primary	10 (8.3)
High school	19 (15.8)
Higher secondary	14 (11.6)
Graduation	69 (57.5)
Post graduation	7 (5.8)
Doctorate	1 (0.8)
Activity pattern:	
Exercise: A) Yes	62 (51.6)
Daily	30
Weekly	5
<3 times in a week	18
Occasionally	9
B) No	58 (48.3)
Type of exercise:	
Yoga	32 (26.6)
Brisk walking	37 (30.8)
Jogging	6 (5)
Cycling	7 (5.8)
Household work:	
Self	33 (27.5)
Shared with family members	12 (10)
Shared with maid	75 (62.5)
Family monthly income (₹):	
1000-10,000	50 (41.6)
10,000-20,000	36 (30)
20,000-30,000	25 (20.8)
>30,000	9 (7.5)

Note: *Figures in Parenthesis indicate percentages

5.1.2: Anthropometric measurements, prevalence of non-communicable diseases (NCDs) and gastrointestinal (GI) problems

Anthropometric measurements and prevalence of NCDs in Gujarati housewives is shown in Figure 5.1.2.1 and 5.1.2.2 respectively. When compared with Asia Pacific BMI standards, the BMI of the subjects revealed that 54.1% subjects were obese and 17.5% subjects were overweight. Almost 18% subjects suffered from GI problems like acidity and constipation. Amongst the various NCDs reported, diabetes, hypertension, and

hypercholesterolemia were prevailed in 7.5, 15.8, and 4.1 per cent subjects respectively.

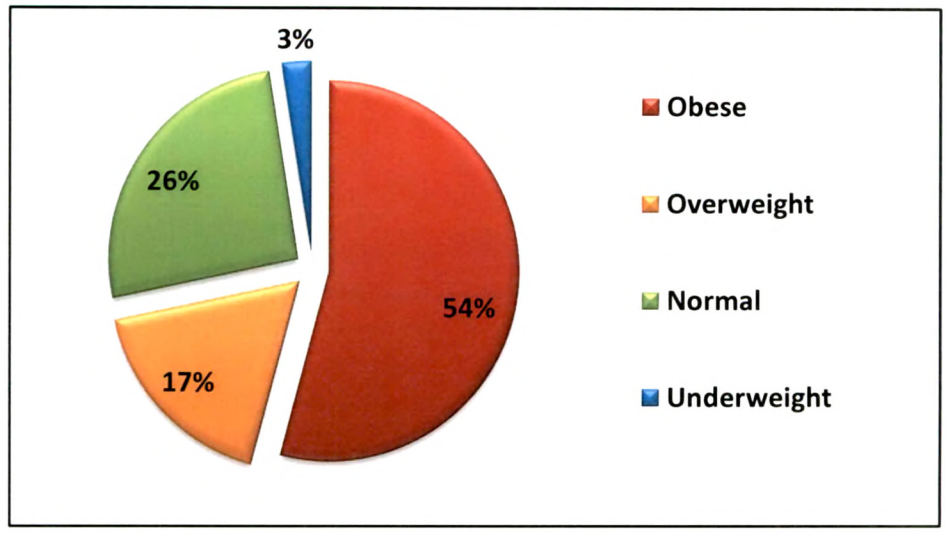


Figure 5.1.2.1: Body mass index classification of Gujarati housewives according to Asia pacific classification

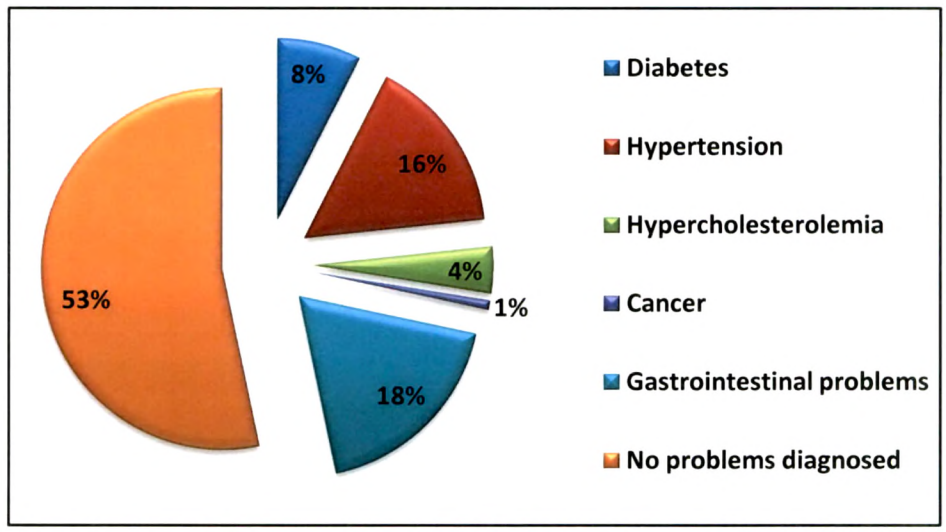


Figure 5.1.2.2: Prevalence of non-communicable diseases and GI problems in Gujarati housewives of urban Vadodara

When the prevalence of NCDs and GI problems of Gujarati housewives was studied for its association with physical activity it was found that obesity and physical activity did not significantly associated at $p<0.05$ level. Similarly, no

association was found between physical activity and other co-morbidities at $p<0.05$ significance level (Table 5.1.2.1).

Table 5.1.2.1: Association between exercise and prevalence of NCDs and GI problems in Gujarati housewives

Exercise	NCDs and GI problems							
	Obesity		Diabetes		Hypertension		GI problems	
	≥25 BMI	<25 BMI	Yes	No	Yes	No	Yes	No
Yes	38	24	3	59	8	54	12	50
No	27	31	6	52	11	47	10	48
Chi-square	$\chi^2=2.62^{NS}$		$\chi^2=1.31^{NS}$		$\chi^2=0.83^{NS}$		$\chi^2=0.09^{NS}$	
Odds ratio	1.82		0.44		0.63		1.15	
CI 95%	L-0.83; U-4.01		L-0.07; U-2.20		L-0.20; U-1.90		L-0.41; U-3.28	

Note: NS-non significant; CI-Confidence Interval

Obesity is implicated in several other disorders and therefore needs to be managed effectively. In the present study, obesity showed significant ($p<0.05$) association and high odds ratio (OR-7.58) with diabetes. However, other co-morbidities showed non-significant association with obesity (Table 5.1.2.2).

Table 5.1.2.2: Association of obesity with other co-morbidities of Gujarati housewives

BMI classification	Hypertension		Diabetes		GI problems	
Obesity	Yes	No	Yes	No	Yes	No
≥25 BMI	13	52	8	57	14	51
<25 BMI	6	49	1	54	8	47
Chi-square	$\chi^2=1.85^{NS}$		$\chi^2=4.73^{*}$		$\chi^2=0.97^{NS}$	
Odds ratio	2.04		7.58		1.61	
CI 95%	L-0.66; U-7.05		L-0.95; U-342. 39		L-0.57;U-4.85	

Note: NS-non significant; *-significant at $p<0.05$; CI-Confidence Interval

5.1.3: Food habits; preferred cooking method for a meal and its frequency

Figure 5.1.3.1 shows the food habits of Gujarati housewives. It can be seen from the graph that 80% of housewives were vegetarian, 12% ovo-vegetarian and only 8.3% of them were non-vegetarian. The survey revealed that for the

preparation of non-vegetarian and ovo-vegetarian foods 90% and 100% housewives preferred shallow fried and deep fried method respectively.

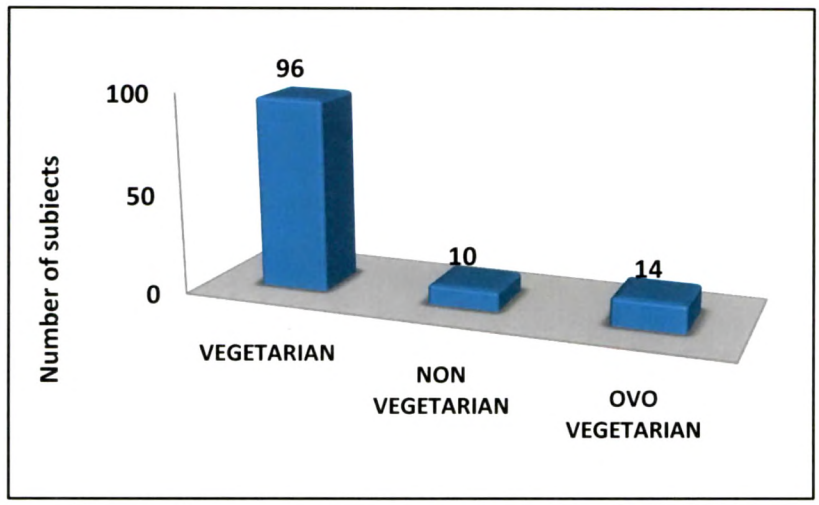


Figure 5.1.3.1: Food habits of Gujarati housewives

Frequency of cooking methods used for preparing a meal is shown in Figure 5.1.3.2. Survey revealed that roasting was used by 92%, sautéing (73%), boiling (51%) and shallow frying (23%) daily for preparing a meal followed by lesser number of subjects using steaming and deep frying daily for cooking purpose. Grilling as a method of cooking was used by only 3% housewives on daily basis. In context to shallow fried and deep fried method used by Gujarati housewives showed that, 24% use these methods 2-3 times a week. Survey also revealed that sautéing was used by 73% of housewives on daily basis for preparing a meal.

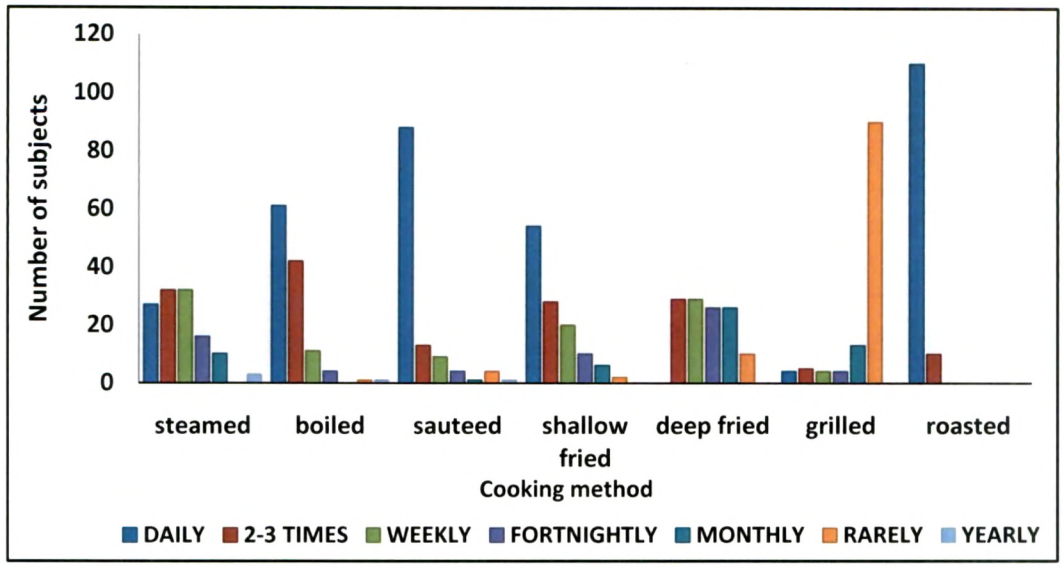


Figure 5.1.3.2: Frequency of cooking methods used for preparing a meal

5.1.4: Consumption pattern of foods prepared at home and its association with prevalence of NCDs and GI problems

Table 5.1.4 shows the consumption pattern of foods prepared at home and its association with prevalence of NCDs and GI problems.

Deep fried foods: Consumption frequency of selected foods by housewives of urban Vadodara revealed that 5% subjects consume deep fried foods daily. 20.8% subjects consumed deep fried foods 2-3 times a week while 55% consumed deep fried foods weekly. In less frequent pattern, 60.8%-82.5% of subjects consumed deep fried foods fortnightly-occasionally. Association between deep fried foods consumption frequency and prevalence of most NCDs was non-significant. However, odds ratio (OR=4.50) showed high association between daily consumption of deep fried food and obesity.

Shallow fried foods: Almost 43% housewives consumed shallow fried foods daily while 30% and 49% housewives consumed shallow fried foods 2-3 times a week and weekly respectively. Significant ($p<0.05$) association and high odds ratio (OR=5.13) was found between daily shallow fried foods consumption and prevalence of diabetes. However, no significant association

was found between consumption of shallow fried foods and other co morbidities.

Deep fried sweets: Deep fried sweets were consumed by only 2.5% on weekly basis and 71.6% of housewives consumed occasionally. No association was found between deep fried sweets consumption and prevalence of NCDs in housewives.

Table 5.1.4: Frequency of consumption of deep fried, shallow fried and deep fried sweets prepared at home and its association with the prevalence of NCDs and GI problems in the Gujarati housewives of urban Vadodara

Frequency	Foods	No. of subjects N (%)	Prevalence of NCDs and GI problems											
			Obesity n=65 N (%)	χ^2	OR	Hypertension n=19 N (%)	χ^2	OR	Diabetes n=9 N (%)	χ^2	OR	Gastrointestinal problems n=22 N (%)	χ^2	OR
Daily	Deep fried §	6 (5)	5 (7.69)	2.16^{NS}	4.50	1 (5.2)	-	-	-	-	-	1 (4.54)	-	-
	Shallow fried ₮	52(43.3)	32 (49.2)	2.01^{NS}	1.70	11 (57.8)	1.95^{NS}	2.01	7 (77.7)	4.70*	5.13	13 (59)	2.72^{NS}	2.19
	Sweets (deep fried)ǂ	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3 times a week	Deep fried §	25 (20.8)	14 (21.5)	0.04^{NS}	1.10	5 (26.3)	0.41^{NS}	1.45	-	-	-	6 (27.2)	-	-
	Shallow fried ₮	36 (30)	20 (30.7)	0.04^{NS}	1.08	5 (26.3)	0.15^{NS}	0.81	1 (11.1)	-	-	6 (27.2)	-	-
	Sweets (deep fried)ǂ	-	-	-	-	-	-	-	-	-	-	-	-	-
Weekly	Deep fried §	66 (55)	33 (50.7)	1.03^{NS}	0.69	13 (68.4)	1.64^{NS}	1.96	5 (55.5)	0.00^{NS}	1.02	11 (50)	0.27^{NS}	0.78
	Shallow fried ₮	59 (49.1)	29 (44.6)	1.18^{NS}	0.67	12 (63.1)	1.77^{NS}	1.97	3 (33.3)	-	-	12 (54.5)	0.31^{NS}	1.30
	Sweets (deep fried)ǂ	3 (2.5)	3 (4.6)	-	-	2 (10.5)	-	-	-	-	-	-	-	-
Fortnightly	Deep fried §	73 (60.8)	40 (61.5)	0.03^{NS}	1.07	14 (73.6)	1.56^{NS}	1.99	7 (77.7)	1.17^{NS}	2.39	14 (63.6)	0.09^{NS}	1.16
	Shallow fried ₮	53 (44.1)	30 (46.1)	0.23^{NS}	1.19	10 (52.6)	0.66^{NS}	1.50	1 (11.1)	-	-	6 (27.2)	-	-
	Sweets (deep fried)ǂ	12 (10)	8 (12.3)	-	-	2 (10.5)	-	-	-	-	-	1 (4.54)	-	-
Monthly	Deep fried §	102 (85)	55 (84.6)	0.02^{NS}	0.94	17 (89.4)	0.35^{NS}	1.60	9 (100)			18 (81.8)	0.21^{NS}	0.75
	Shallow fried ₮	74 (61.6)	39 (60)	0.17^{NS}	0.86	11 (57.8)	0.14^{NS}	0.83	6 (66.6)	0.10^{NS}	1.26	13 (59)	0.08^{NS}	0.88
	Sweets (deep fried)ǂ	27 (22.5)	13 (20)	0.51^{NS}	0.73	4 (21)	-	-	1 (11.1)	-	-	5 (22.7)	-	-
Occasionally	Deep fried §	99 (82.5)	51 (78.4)	0.01^{NS}	0.97	19 (100)	-	-	6 (66.6)	1.69^{NS}	0.39	18 (81.8)	0.01^{NS}	0.94
	Shallow fried ₮	74 (61.6)	38 (58.4)	0.62^{NS}	0.74	12 (63.1)	0.02^{NS}	1.08	6 (66.6)	0.10^{NS}	1.26	12 (54.5)	0.58^{NS}	0.70
	Sweets (deep fried)ǂ	86(71.6)	44 (67.6)	1.10^{NS}	0.65	13 (68.4)	0.12^{NS}	0.83	6 (66.6)	0.12^{NS}	0.77	17 (77.2)	0.42^{NS}	1.43

§- Chips, French fries, Samosa, Cutlet, Breadrolls, Kachori, Bhajia, Vada, Meduvada, Mathri, Namakpara, Chiwda, Chanadal, Moongdal, Puri, Bhatura, Faafda; ₮-Bhakri, Pav bhaji, Bhalle, Sev khamni, Burgers, Hotdogs, Cheela; ǂ- Gulabjamun, Jalebi, Mysorepak, Boondi laddo; NS-non significant; *p=<0.05, OR=Odds ratio; Figures in Parenthesis indicate percentages

5.1.5: Consumption pattern of fried foods purchased from market and its association with prevalence of NCDs and GI problems

Table 5.1.5 shows the results of consumption pattern of deep and shallow fried foods purchased from market and its association with prevalence of NCDs and GI problems.

Deep fried foods: Consumption frequency of selected foods purchased by housewives of urban Vadodara showed that only 3 out of 120 subjects consumed deep fried foods daily. Amongst the subjects who subjects purchased deep fried foods daily 2 were not obese. In frequent consumption pattern (2-3 times of week) of fried foods purchased from market, 9 (13.84%) were obese, 2 (10.52%) had hypertension, about 3 (30%) had diabetes and 3 (13.6%) subjects were frequent suffered from gastrointestinal problems. However, chi-square showed no significant association between deep fried food consumption and prevalence of NCDs. 40-70% subjects consumed deep fried foods weekly-fortnightly. Chi-square showed a significant ($p<0.05$) association between gastrointestinal problems and fortnightly consumption of deep fried foods.

Shallow fried foods: Consumption of shallow fried foods was found in 4 (3%) subjects out of whom 3 (4.61%) subjects were obese. Weekly consumption of shallow fried foods was found in 9% subjects. However, no significant association was found in consumption of shallow fried foods and co-morbidities. High odds ratio (OR), 2.18 was found in weekly shallow fried consumption and hypertension. Occasional consumption of shallow fried foods showed a significant ($p<0.05$) association with hypertension.

Deep fried sweets: Consumption of deep fried sweets was found only in 5% subjects on weekly basis. 17% subjects were obese who consumed deep fried sweets monthly. Association between monthly consumption of deep fried sweets and obesity was significant at $p<0.05$ level. Diabetes also showed a significant ($p<0.05$) association with occasional consumption of deep fried sweets.

Table 5.1.5: Frequency of consumption of deep fried, shallow fried and deep fried sweets purchased from market and its association with the prevalence of NCDs and GI problems in the Gujarati housewives of urban Vadodara

Frequency	Foods	No. of subjects N (%)	Prevalence of NCDs and GI problems											
			Obesity n=65 N (%)	χ^2	OR	Hypertension n=19 N (%)	χ^2	OR	Diabetes n=9 N (%)	χ^2	OR	Gastrointestinal problems n=22 N (%)	χ^2	OR
Daily	Deep fried §	3 (2.5)	1 (1.53)	-	-	-	-	-	-	-	-	-	-	-
	Shallow fried ₮	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sweets (deep fried)ᴴ	-	-	-	-	-	-	-	-	-	-	-	-	-
2-3 times a week	Deep fried §	15 (12.5)	9 (13.84)	0.28 NS	1.35	2 (10.52)	0.08NS	0.80	3 (33.33)	0.03 NS	0.89	3 (13.63)	0.03 NS	1.13
	Shallow fried ₮	4 (3.33)	3 (4.61)	-	-	-	-	-	-	-	-	1 (4.54)	-	-
	Sweets (deep fried)ᴴ	-	-	-	-	-	-	-	-	-	-	-	-	-
Weekly	Deep fried §	43(35.83)	22(33.84)	0.24 NS	0.83	6 (31.57)	0.18NS	0.80	3 (33.33)	0.03 NS	0.89	7 (31.81)	0.12 NS	0.84
	Shallow fried ₮	11(9.16)	6 (9.23)	0.00 NS	1.02	3 (15.78)	1.19NS	2.18	-	-	-	1 (4.54)	-	-
	Sweets (deep fried)ᴴ	6 (5)	5 (7.69)	-	-	2 (10.52)	-	-	-	-	-	1 (4.54)	-	-
Fortnightly	Deep fried §	49(40.83)	25(38.46)	0.33 NS	0.81	9 (47.36)	0.40NS	1.37	3 (33.33)	0.28 NS	0.68	5 (22.72)	3.98*	0.35
	Shallow fried ₮	24(20)	14(21.53)	0.21 NS	1.24	4 (21.05)	0.02NS	1.08	3 (33.33)	0.25 NS	0.71	5 (22.72)	0.13 NS	1.22
	Sweets (deep fried)ᴴ	9(7.5)	6 (9.23)	0.61 NS	1.76	1 (5.26)	-	-	-	-	-	2 (9.09)	0.10 NS	1.30
Monthly	Deep fried §	88(73.33)	44(67.69)	2.31 NS	0.52	15 (78.94)	0.36NS	1.44	9 (100)	-	-	16 (72.72)	0.01 NS	0.96
	Shallow fried ₮	48(40)	25(38.46)	0.14 NS	0.87	10 (52.63)	1.50NS	1.04	2 (22.22)	1.28 NS	0.40	6 (27.27)	1.82 NS	0.50
	Sweets (deep fried)ᴴ	30(25)	11(16.92)	4.93*	0.39	5 (26.31)	0.02NS	1.09	2 (22.22)	0.04 NS	0.85	5 (22.72)	0.07 NS	0.86
Occasionally	Deep fried §	80(25)	42(64.61)	0.27 NS	0.82	13 (68.42)	0.01NS	1.05	7 (77.77)	0.54 NS	1.82	17 (77.27)	1.17 NS	1.81
	Shallow fried ₮	59(49.16)	29(44.61)	1.18 NS	0.67	5 (26.31)	4.72*	0.31	5 (55.55)	0.16 NS	1.32	13 (59.09)	1.06 NS	1.63
	Sweets (deep fried)ᴴ	90(7.5)	47(72.30)	0.55 NS	0.73	14 (73.68)	0.02NS	0.92	4 (44.44)	4.84*	0.23	15 (68.18)	0.67 NS	0.66

§- Chips, French fries, Samosa, Cutlet, Breadrolls, Kachori, Bhajia, Vada, Meduvada, Mathri, Namakpara, Chiwda, Chanadal, Moongdal, Puri, Bhatura, Faafda; ₮- Bhakri, Pav bhaji, Bhalle, Sev khamni, Burgers, Hotdogs, Cheela; H- Gulabjamun, Jalebi, Mysorepak, Boondi laddo; NS-non significant; *p=<0.05, OR=Odds ratio; Figures in Parenthesis indicate percentages

5.1.6: Eating out frequency; preferred cooking methods and foods preferred during long distance travelling

Rapid industrialization and change in life styles of people has resulted in marked increase in the consumption of food outside the house. Figure 5.1.6.1 shows the eating out frequency in restaurants/parties of Gujarati housewives. In the present study it was found that more than a quarter per cent (34%) housewives prefer eating out monthly in restaurants/parties. Weekly eating out frequency was observed in more than 20% Gujarati housewives. However, 7% never preferred eating in restaurants or parties.

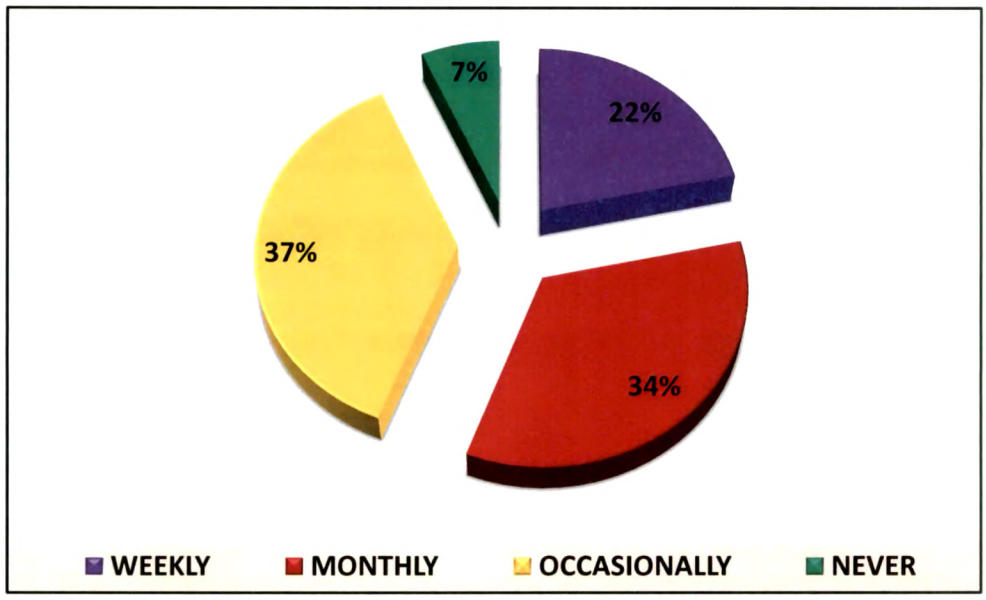


Figure 5.1.6.1: Eating out frequency of Gujarati housewives in parties/ restaurants

Chi-square was applied to find out if any association exists between eating out frequency, prevalence of NCDs and GI problems in Gujarati housewives shown in Table 5.1.6. Weekly, monthly and occasionally eating out frequency showed no significant association between obesity, hypertension, diabetes and GI problems. However, diabetes and GI problems showed high odds ratio of OR 2.60 and 2.27 respectively with monthly eating out frequency.

Table 5.1.6: Association between eating out frequency and prevalence of NCDs and GI problems in Gujarati housewives

Eating out frequency		Prevalence of NCDs and GI problems							
		Obesity		Hypertension		Diabetes		GI problems	
		Yes	No	Yes	No	Yes	No	Yes	No
Weekly	Yes	15	11	6	20	-	-	3	23
	No	50	44	13	81	-	-	19	75
Chi-square		χ^2=0.17 NS		χ^2=1.31 NS		-		χ^2=1.02 NS	
Odds ratio		1.20		1.87		-		0.51	
CI 95%		L-0.46;U-3.21		L-0.51;U-6.08		-		L-0.09;U-2.0	
Monthly	Yes	18	23	5	36	5	36	11	30
	No	47	32	14	65	4	75	11	68
Chi-square		χ^2=2.64 NS		χ^2=0.62 NS		χ^2=1.98 NS		χ^2=3.00 NS	
Odds ratio		0.53		0.64		2.60		2.27	
CI 95%		L-0.23;U-1.22		L-0.17;U-2.10		L-0.52;U-13.83		L-0.79;U-6.45	
Occasio-nally	Yes	26	19	5	40	-	-	6	39
	No	39	36	14	61	-	-	16	59
Chi-square		χ^2=0.38 NS		χ^2=1.20 NS		-		χ^2=1.20 NS	
Odds ratio		1.26		0.54		-		0.57	
CI 95%		L-0.56;U-2.85		L-0.14;U-1.77		-		L-0.17;U-1.70	

Note: NS-non significant; CI-Confidence Interval

Various methods are used for cooking foods stuffs at home and outside home as well. Figure 5.1.6.2 shows the most preferred foods while eating outside home in terms of cooking methods employed.

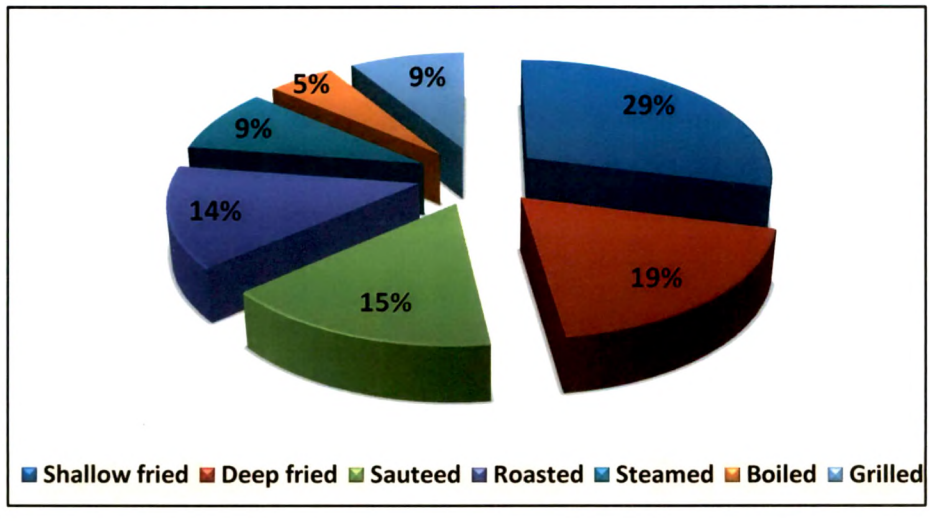


Figure 5.1.6.2: Most preferred food while eating outside

While eating outside most (29%) of the housewives preferred shallow fried foods and 19% housewives preferred deep fried foods. It can be seen that roasted foods were preferred by 14% housewives. Other cooking methods like boiling, grilling and steaming were preferred by 5%, 9% and 9% respectively.

Generally in every part of the world during long distance travelling people take food with them or purchase from the available sources. Here Figure 5.1.6.3 shows the preference of food during long distance travelling of Gujarati housewives. Data shows that most (82%) of the Gujarati housewives prefer homemade food and only 18% prefer ready-to-eat (RTE) foods during long distance travelling.

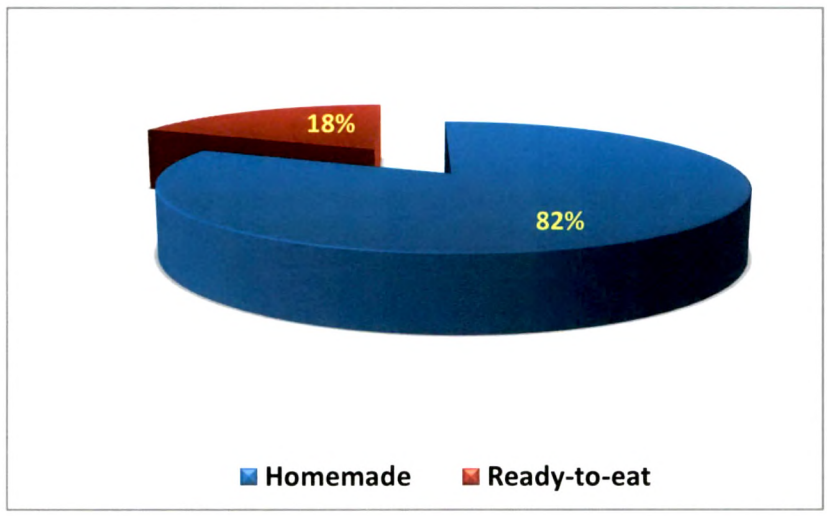


Figure 5.1.6.3: Type of food preferred during long distance travelling

5.1.7: Oil consumption pattern, its use and association with prevalence of NCDs and GI problems

On the basis of oil purchased for household usage, the average monthly per capita intake was calculated as 1.39kg and it ranged from 0.33-5kg. While the daily per capita intake calculated as 40g. As shown in Table 5.1.7.1, 38.3% of Gujarati families use both mono and polyunsaturated rich oil for cooking and nearly 25% of families use only monounsaturated rich oil (groundnut oil). With regards to saturated fats, it was found that 24.1% of families used

vanaspati for cooking purposes along with other types of saturated fats. Butter was used by about 76% and ghee was used by all the families.

Table 5.1.7.1: Type of oil used by Gujarati housewives for cooking per month in kg (kilogram)

Type of oil used for cooking	
Oil type	**No (%)**
Unsaturated	
Mono+Poly	46 (38)
Mono	29 (24)
Poly	45 (37.5)
Saturated	
Ghee	120 (100)
Butter	91 (75.8)
Vanaspati	29 (24)

Note: Figures in Parenthesis indicate percentages; Mono-monounsaturated; Poly-polyunsaturated

Consumption of *vanaspati* showed a significant ($p<0.001$) association and high odds ratio (OR=4.80) with hypertension as shown in Table 5.1.7.2. However, chi-square showed no significant association with other morbidities and *vanaspati* consumption. Table 5.1.7.3 shows the association between butter consumption and prevalence of NCDs. No significant association was found between butter consumption and prevalence of NCDs and GI problems.

Table 5.1.7.2: *Vanaspati* consumption and its association with prevalence of NCDs and GI problems

Vanaspati Consumption	Obesity		Hypertension		Diabetes		GI problems	
	Yes	No	Yes	No	Yes	No	Yes	No
Yes	17	12	10	19	4	25	3	26
No	48	43	9	82	5	86	19	72
Chi-square	$\chi^2=0.31^{NS}$		$\chi^2=9.98^{***}$		$\chi^2=2.18^{NS}$		$\chi^2=1.63^{NS}$	
Odds ratio	1.27		4.80		2.75		0.44	
CI 95%	L-0.50;U-3.27		L-1.50;U-15.22		L-0.50;U-13.74		L-0.08;U-1.68	

Note: *-Significant at p<0.001; NS-non significant; CI-Confidence Interval**

Table 5.1.7.3: Butter consumption and its association with prevalence of NCDs and GI problems

Butter Consumption	Obesity		Hypertension		Diabetes		GI problems	
	Yes	No	Yes	No	Yes	No	Yes	No
Yes	47	44	16	75	6	85	18	73
No	18	11	3	26	3	26	4	25
Chi-square	χ^2=0.96 NS		χ^2=0.86 NS		χ^2=0.45 NS		χ^2=0.53 NS	
Odds ratio	0.65		1.85		0.61		1.54	
CI 95%	L-0.25;U-1.66>		L-0.47;U-10.64		L-0.12;U-4.06		L-0.45;U-6.83	

Note: NS-non significant; CI-Confidence Interval

Knowledge on oil intake and perception of subjects regarding consequences of excessive fried food intake is shown in Table 5.1.7.4; it was found that 23% of housewives knew correct recommended oil intake/person/day, while rest of the subjects reported low or higher quantities of oil. Almost 40.8% subjects did not know about the recommended daily allowances of oil. Most of housewives reported obesity (11%), heart disease (18%) and both answered obesity and heart disease (29.1%) as consequences of excessive consumption of fried foods. However, 15.8% did not know the consequence of intake of excessive fried foods.

Table 5.1.7.4: Knowledge on daily intake of edible oil by Gujarati housewives and their perception regarding health consequences of excessive fried food intake

Knowledge on amount of oil required/day/person	
Amount of oil required/day/person	No. (%)
10-20g	23 (19.17)
20-30g	28 (23.33)
40-60g	15 (12.5)
60-80g	2 (1.67)
No limit	3 (2.5)
Do not know	49 (40.83)
Perception of subjects regarding consequences of consuming excessively fried foods	**No. (%)**
Obesity	14 (11.6)
Heart disease	22 (18.3)
Gastrointestinal problems (GIT)	13 (10.8)
Obesity and heart disease	35 (29.1)
Heart disease and GIT	4 (3.3)
Obesity and GIT	4 (3.3)
Cancer	9 (7.5)
Do not know	19 (15.83)

Note: Figures in Parenthesis indicate percentages

5.1.8: Use of leftover fried oil, containers used for oil storage and practices of storing fried oil

Use of fried oil at household level and its association with their morbidity profile are shown in Table 5.1.8.1 and 5.1.8.2 respectively. It was found that 62.5% of people used leftover fried oil for sautéing vegetables and shortening while 16.7% subjects never used it for refrying purpose. 70.8% of the housewives store oil in steel containers. However, 5% of housewives used other containers like aluminum jars. Occurrence of non-communicable diseases and GI problems did not show any significant association with refrying practices.

Table 5.1.8.1: Use of leftover fried oil and containers use for storage

Use of left over fried oil	No. (%)
Add more fresh oil for refrying	13 (10.8)
Discard frying oil	20 (16.67)
Use fried oil for sautéing vegetable preparations	75 (62.5)
Refry the same oil without adding more	12 (10)
Container for oil storage	
Steel jars	85 (70.83)
Plastic containers (opaque)	17 (14.17)
Aluminum	6 (5)
Plastic transparent jar	8 (6.67)
Glass jars	4 (3.3)

Note: Figures in Parenthesis indicate percentages

Table 5.1.8.2: Association between frying practices and prevalence of NCDs and GI problems in Gujarati housewives

Refrying practice	HT		GI problems		Obesity	
	Yes	No	Yes	No	Yes	No
Not refrying	3	18	3	18	12	9
Refrying	16	83	18	81	53	46
Chi-square	$\chi^2=0.05^{NS}$		$\chi^2=0.18^{NS}$		$\chi^2=0.09^{NS}$	
Odds ratio	0.86		0.75		1.16	
CI 95%	L-0.15;U-3.51		L-0.13;U-3.0		L-0.40;U-3.41	

Note: NS-non significant; CI-Confidence Interval

Figure 5.1.8 shows the fried oil storage practices of the subjects revealed that 51.6% of the subjects store the left over fried oil after filtration and 20.8% never stored fried oil.

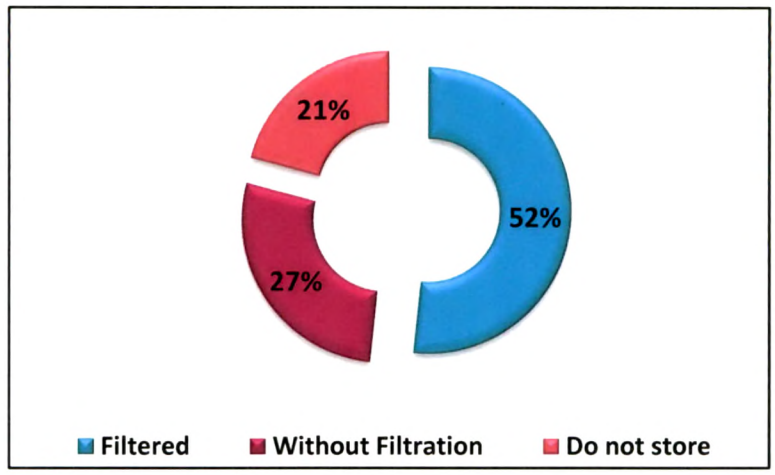


Figure 5.1.8: Practices of housewives for storing fried oil

5.1.9: Knowledge on refrying and filtration of fried oil before storage

As shown in Table 5.1.9, it was found that 58.3% subjects reported that fried oil can be refried and 41.6% subjects do not refry fried oil. However, 20% subjects answered oil should be fried for once only, and 4% said oil can be fried more than 4 times and considered safe for consumption. Knowledge on filtration of fried oil before storage revealed that most housewives (54%) felt that filtration is essential to remove the fried particles and to prevent the changes occurring from the leftover fried particles in oil. 69% of house wives filter fried oil before storage. However, 12.5% subjects believed that filtration is essential to remove dust from the oil.

Table 5.1.9: Knowledge on refrying and filtration of fried oil before storage

Knowledge on refrying	**No. (%)**
Not to refry	24 (20)
Two times	23 (19.17)
Three times	12 (10)
Four times	6 (5)
More	5 (4.17)
Reasons for filtration of fried oil before storage	**No (%)**
To remove small fried particles	65 (54.17)
To remove dust	15 (12.5)
To clean oil	3 (2.5)

Note: Figures in Parenthesis indicate percentages

5.1.10: Changes observed in fresh oil upon frying and storage of fresh oil

Figure 5.1.10, shows the most common changes noticed in the fried oil were color change (34.1%), thickening (18%) and gumming (9.1%). However, 12.5% never noticed any changes in fried oil. Changes in fresh oil shown in Table 5.1.10 were noticed by only 39% of surveyed housewives and 61% never noticed any change in fresh oil upon long term storage. Moreover, common changes in fresh oil noticed by housewives were color change-11.6%, foul odor-16.7% and thickening of oil-10.8%.

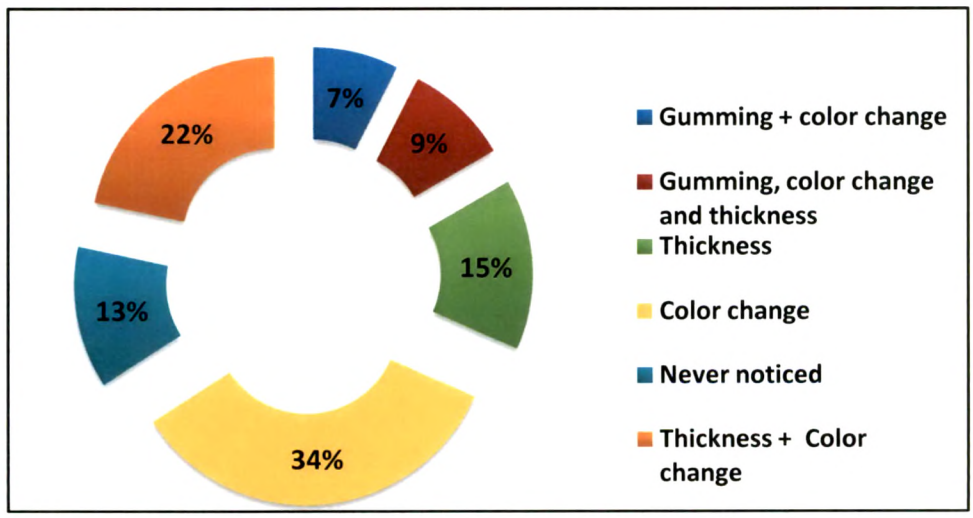


Figure 5.1.10: Changes observed in fresh oil upon frying

Table 5.1.10: Changes observed in fresh oil upon storage of fresh oil

Changes in fresh oil upon long term storage	No. (%)
Change in color	14 (11.67)
Foul odor	20 (16.67)
Thickening of oil	13 (10.83)
Do not notice any change	73 (60.83)

Note: Figures in Parenthesis indicate percentages

5.1.11: Knowledge on oil blends and *trans* fats

Blended oils are good source of essential fatty acids. However, knowledge on blend oils still need to be more popularized. In present study 82.5% of housewives did not know about the oil blends (Figure 5.1.11.1). Moreover, 10.8% housewives answered that oil blends are combination of two or more oils. Knowledge on *trans* fats of Gujarati housewives showed that 24% knew about the *trans* fats (Figure 5.1.11.2).

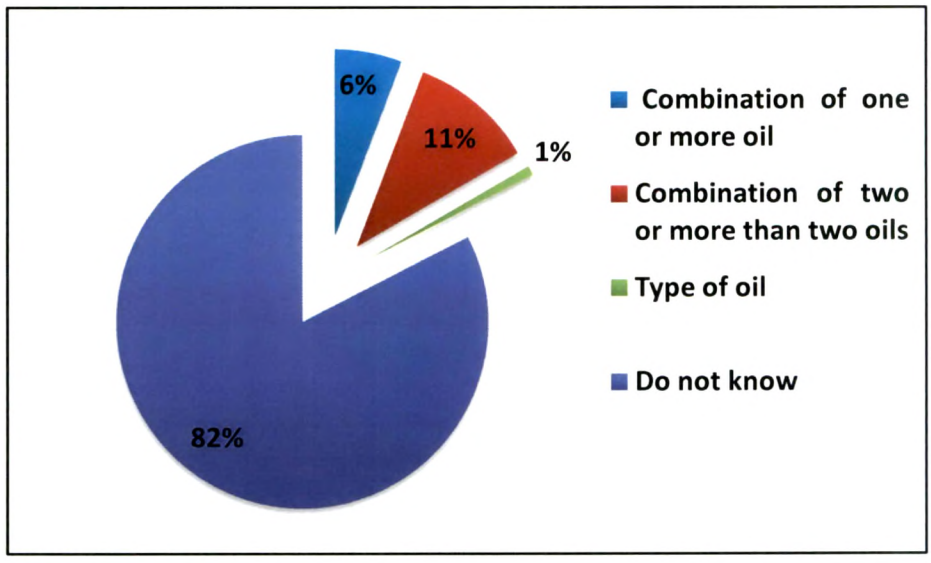


Figure 5.1.11.1: Knowledge on oil blends

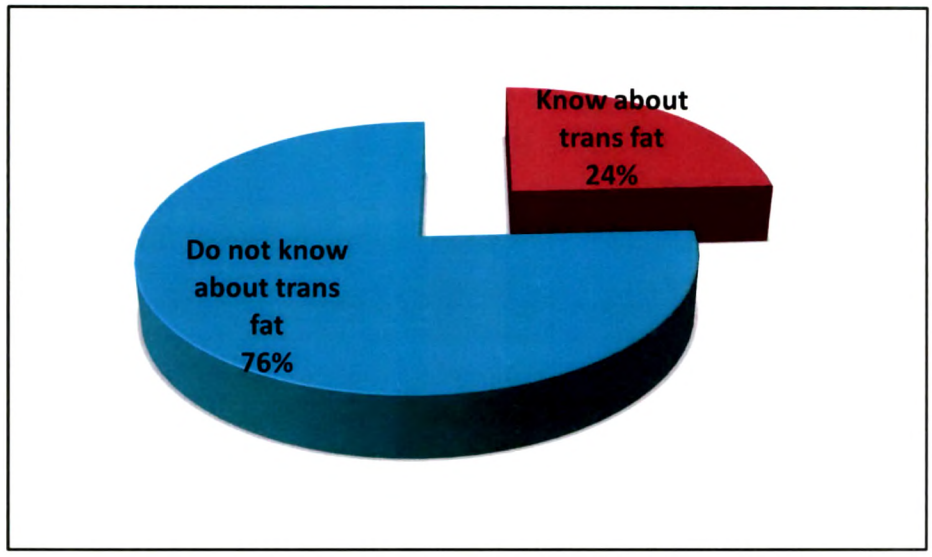


Figure 5.1.11.2: Knowledge on trans fats of Gujarati housewives

Results of the present study showed that, 75.8% housewives did not know about health effects of oil blends, while 13.3% of housewives considered oil blends to be good for health (Table 5.1.11.1).

Table 5.1.11.1: Knowledge on oil blends and *trans* fats of Gujarati housewives

Knowledge on oil blends and their health effects	**No (%)**
Good for health	16 (13.33)
Not good for health	13 (10.83)
Do not know	91 (75.83)
Knowledge on *trans* fat	**No (%)**
Harmful to health	20 (16.67)
Beneficial to health	3 (2.5)
Adds taste to the diet	4 (3.33)
No effect on health	2 (1.67)
Do not know	91 (75.83)

Note: Figures in Parenthesis indicate percentages

It was found that 75.8% did not know about *trans* fats and its food sources (Table 5.1.11.2). Only 16.6% knew that *trans* fat is a form of fat which is harmful to health. No significant association was observed between the education levels of the subject and knowledge about *trans* fats.

Table 5.1.11.2: Education profile association with knowledge on *trans* fats

Knowledge on trans fat	Primary	High school	Higher secondary	Graduation	Post graduation	Total
Yes	1	2	2	21	3	29
No	9	17	12	48	5	91
Total	10	19	14	69	8	120
Chi-square				$\chi^2=6.02^{NS}$		

Note: NS-non significant

PHASE I - RESULT HIGHLIGHTS

- *The background information regarding the subjects revealed that most of them belong to middle income group and about 57.5% housewives were graduate.*
- *Regarding the fried food consumption pattern deep fried products prepared at home were consumed by 5% of households on daily basis and 55% and 60% households consumed fried foods on a weekly and fortnightly basis. Shallow fried foods were consumed by 43% of households on daily basis and 49% and 44% consumed shallow fried foods weekly and fortnightly basis. None of the households consumed deep fried sweets on daily basis.*
- *Prevalence of obesity was found in 54% of the Gujarati housewives. Other co-morbidities related to obesity such as hypertension and diabetes were present in 16% and 8% housewives respectively. Significant association was seen between diabetes and obesity.*
- *Most of the surveyed subjects were vegetarian and resorted to roasting as most popular cooking method.*
- *Homemade shallow fried foods consumption significantly correlated with diabetes.*
- *Fried food purchased from market fortnightly and its consumption showed a significant association with prevalence of GI problems.*
- *22% Gujarati housewives preferred eating out in restaurants/ parties on a weekly basis and 7% never preferred eating out. However, no association was found between prevalence of NCDs, GI problems and eating out frequency.*
- *Many families reported daily use of saturated fats such as vanaspati (26%), ghee (100%) and butter (76%). Use of vanaspati showed a significant association ($p<0.001$) with prevalence of hypertension. However, consumption of butter did not show association with prevalence of NCDs and GI problems.*
- *Use of leftover fried oil was used for sautéing by most families and no association was found between refrying practices and health ailments.*
- *Very few housewives knew about oil blends and trans fats.*

DISCUSSION

Gujarat is considered as one of the rich and developed states of India. Ethnic Gujarati people are presumed to have high prevalence of Coronary artery disease (CAD) risk factors namely obesity, diabetes, hypertension, dyslipidemia, because of traditional fat and sugar rich Gujarati food and sedentary life style. A study carried out in Gujarat revealed that 61.3% of rural diabetes patients were obese. The female subjects had greater prevalence of obesity (84%) than their male counterparts (58%). Similar trend was seen in urban areas (M: 88%, F: 71%) (Pandya H, Lakhani JD and Patel N, 2011). However, in the present study conducted in urban Vadodara, the rate of prevalence of obesity was lower (54%) than the one cited in the above study. This could possibly be because of the choice of subjects (housewives), who (50%) were engaged in some sort of physical activities such as yoga and brisk walking. Studies have shown that physical activity is significantly associated with reduced rates of obesity (Frank LD, Andresen MA and Schmid TL, 2004). Studies have shown that fried food was positively associated with obesity only among subjects in the highest quintile of energy intake from fried food (Guallar CP et al, 2007). In the present study, high prevalence of obesity (54%) was observed which could be due to frequent consumption of fried and shallow fried foods (2-3 times per week to weekly).

Incidences of obesity and co-morbidities in the present study showed a significant ($p<0.05$) association between obesity and diabetes. These findings are also supported by a recent study conducted in Vadodara region which revealed that almost 70% of diabetic patients were obese. Interestingly authors of the study used "Diabesity" as a synonym for diabetes in Gujarati population (Pandya H, Lakhani JD and Patel N, 2011). Thus, these findings are in accordance with the studies indicating an interrelationship between obesity and diabetes (Misra A and Khurana L, 2008; Qiao Q and Nyamdorj R, 2010; Manimunda SP et al, 2011).

Prevalence of obesity (54%) and hypertension (16%) in present work shows high odds ratio (OR=2.04; 95% confidence limit=7.05, 0.66). A study on prevalence of obesity and hypertension in urban Tamilnadu by Gupta M et al (2011) showed a significant correlation between body weight, BMI and systolic blood pressure. In 2004, it was reported that the average prevalence of hypertension in India was 25% in urban and 10% in rural inhabitants (Gupta R, 2004). Studies carried out on the tribal (Lepchas of Sikkim in Himalayas, tribes of Andhra Pradesh, Gujarat, and Orissa) and labor (Bareilly district-Uttar Pradesh, Gujarat) populations of India documented hypertension prevalence in the range of 15 to 42 per cent, 10.81% and 16.9% respectively. (Manimunda SP et al, 2011; Mahmood SE et al, 2011; Tiwari RR, 2008).

Present study showed 21.5% obesity in Gujarati housewives who consumed deep fried foods 2-3 times a week at home. A study conducted on dietary patterns of adults living in Ouagadougou showed daily consumption of fried and modern foods have positive association (OR=1.11; significant at $p<0.01$) with overweight and fatness (Becquey E et al, 2010). Another study conducted in multicultural society of Mauritius eating practices revealed that 83% urban population do not adhere to the WHO advised guidelines, to consume deep fried and fried foods sparingly (Krige SM et al, 2012).

In the present study, 22 per cent and 34 percent housewives preferred eating out weekly and monthly respectively. In a recent pilot study on Mauritian population revealed that frequency of meals eating out of home, 1-3 times per week was 33.4% for lunch and 26.2% for dinner (Krige SM et al, 2012). Another study on fast foods consumption in young adults (n=341) of Johannesburg revealed 11 per cent participants consume fast foods daily whereas 27.6 per cent consumed fast foods 2-3 times a week (Van Zyl MK, Steyn NP and Marais ML, 2010).

The association between prevalence of NCDs and eating out frequency showed no significant difference. In addition, several researches identified, away from home foods and restaurant meals as a potential cause of obesity

(McCrory MA et al, 1999; French SA, Harnack L and Jeffery RW, 2000), others pointed to the key role of between-meal snacks (Zizza C, Siega-Riz AM and Popkin BM, 2001) and growing portions of foods consumed at home (Drewnowski A and Darmon N, 2005).

In the present study, amongst the most preferred cooking methods during eating outside home, shallow fried was preferred by 63 subjects followed by deep fried (41 subjects). These results show the popularity and preference of fried foods in the surveyed population. Further, the present findings showed consumption of ready-to-eat foods during long distance travelling by 18.3% subjects. In an Indian study, it was found that ready-to-eat foods like fried fries, pizza, burgers were most popular food items consumed by adolescents and young adults in New Delhi (Mahna R, Passi SJ, and Khanna K, 2004). In another study conducted in Johannesburg showed consumption of fast foods namely burgers (69.5%), pizza (56.6%), fries (37%) and fried chicken (36.8%) was popular in interviewed subjects (Van Zyl MK, Steyn NP and Marais ML, 2010). The reason for asking the food preference during long distance travelling is to observe the peoples fondness due to convenience and taste of such foods.

With economic development, and driven by potential economies of scale, super markets tend to replace central food markets, neighborhood stores and street sellers of food in urban areas. Supermarkets are also becoming an emerging force in South Asia, particularly in urban India since the mid-1990s (Pingali P and Khwaja Y, 2004). Report by Pingali P and Khwaja Y (2004) showed that consumption of more energy dense foods and thus, typically, calorie intake has gone up substantially in Asian region particularly in higher income groups. Fried foods contain a considerable amount of fat, and have a negative perceived image due to their high caloric value and increased consumer awareness of the relationship between food, nutrition, and health (Dana D and Saguy IS, 2001).

Present work also focused on understanding the knowledge of Gujarati housewives on changes that take in fried oil, wherein almost 60% housewives did not report of noticing any changes in fried oil. This could possibly be due to their good frying practices as most housewives (90%) rarely reused the fried oil. Ambiguity on the extent of refrying needs to be studied more extensively involving larger population, so that food safety recommendations can be made for profit gaining set ups and at household levels. Frying oil undergoes three main deleterious reactions: oxidation, hydrolysis and thermal decomposition, resulting in the formation of numerous constituents (Dana D and Saguy IS, 2001). Other than chemical changes in fried oil, the main criteria for discontinuing the use of frying oils are color, viscosity and foaming (Ohta S, 1985). Refrying in same oil tends to release some harmful components which may adversely affect health (Crampton EW et al, 1952). The present practice of refrying at household level showed no association with prevalence of NCDs in Gujarati housewives.

Bulletin of the Nutrition Foundation of India reported that fat consumption is higher in prosperous urbanized states like Gujarat, Haryana and Punjab when compared with other States of India (Ramachandran P, 2008). Although results of the present study showed that oil purchased by the Gujarati housewives was within the recommended limits given by NIN. However, much more quantity of oil is likely to be consumed by Gujarati housewives. This does not take into consideration the oil intake from the fried foods purchased from the market. Thus a larger quantity of invisible intake of oil from the purchased fried foods may be the cause for 54% obesity in the present study. Adequate intake of oil may thus be attributed to low prevalence of NCDs except obesity. However, this needs to be validated using a larger sample size.

In this study the housewives did not report changes in stored oil. Storage of fresh oil for longer duration leads to several changes like- color change, foul odor etc (Premavalli KS, Madhura CV, and Arya SS, 1998). In the present

survey results showed that maximum housewives stored fresh oil stainless steel containers and plastic jars. Storage of fresh oil in plastic containers and glass jars were practiced by 14% and 3% respectively. Results of few studies have shown that tin plate containers are best for edible oil packaging (Tismis DA, and Karakasides NG, 2002).

The present study throws light on the limited knowledge of the housewives regarding *trans* fats and its sources and no association was found between their education level and their knowledge on *trans* fats. Some investigators have found that in many parts of India, *trans* fat rich hydrogenated vegetable oil (popularly called *vanaspati)* are consumed in greater quantities than in the United States (Willett WC, Ascherio A, 1994; Singh RB et al, 1996). In view of the fact the *trans* fats beyond certain limits are a risk to CVDs, the need for consumer education is a imperative to safeguard the growing prevalence of heart diseases (Sundaram K, 1997; Mozaffarian D, Aro A and Willet WC, 2009).

To conclude, high incidence of obesity with prevalence of other co-morbidities may be attributed to consumption of fats such as ghee on daily basis and frequent intake of fried and shallow fried foods. Most subjects did not have knowledge on recommended daily intake of oils and *trans* fats. Hence education on recommended intakes of oil along with its correct use and blend may perhaps be a good option to reduce overall prevalence of NCDs.

PHASE II

5.2: SENSORY QUALITIES OF FRENCH FRIES AND BHAJIAS FRIED IN COTTONSEED OIL (CSO) AND GROUNDNUT OIL (GNO) DURING INTERMITTENT FRYING

Fried foods have become more and more popular in spite of the present guidelines which recommend to decrease the level of fat in the diet. The main reason for this is that frying is a fast and convenient technique for production of foods with unique sensory properties of color, flavor, texture, and palatability, highly appreciated by consumers. The simultaneous heat and mass transfer of oil, food, and air during frying produces desirable and unique quality in the fried foods. These positive changes are accompanied by some undesirable modifications of the frying medium. It is very well known that, during deep-frying, thermal, oxidative, and hydrolytic reactions take place and, thus, physical and chemical changes in the oil or fat are expected to occur as a consequence of the formation of new compounds. These changes in turn may affect the sensory qualities of products fried in it.

In this phase of the study, sensory evaluation of french fries and bhajias was carried out at 0, 6, 11, 16 and 21 h of intermittent frying (Plate 5.2.1.1). 25 (Twenty five) semi-trained sensory panelists who were familiar with the quality of french fries and bhajias were selected as described in Methods and Material chapter 3. Freshly fried (hot) french fries and bhajias were judged for appearance, color, crispness, greasiness, flavor, taste, odor, and overall acceptability. French fries and bhajias were evaluated on 9-point hedonic scale for their organoleptic qualities. The results of this phase are presented under the following heads:

5.2.1: Sensory quality of french fries fried in CSO and GNO at intermittent durations.

5.2.2: Sensory quality of bhajias fried in CSO and GNO at intermittent durations.

5.2.3: Comparison of french fries (non-coated) and bhajias (batter coated) fried in CSO and GNO for difference in their sensory mean scores.

5.2.4: Oil uptake by french fries and bhajias fried in CSO and GNO at 25 h of intermittent frying.

5.2.1: Sensory quality of french fries fried in CSO and GNO at intermittent durations

Figure 5.2.1.1 shows the mean sensory scores of french fries for appearance, color, crispness and greasiness fried in CSO and GNO. F-test (ANOVA) showed no significant difference in mean sensory scores for appearance, color, and crispness of french fries fried in CSO and GNO during and at the end of 21 h intermittent frying period. However, crispness scores of CSO fried fries were significantly high ($p<0.05$) at 11 h as compared to GNO (Table 5.2.1.1).

Greasiness an important undesirable attribute in fried foods is significantly influenced by the quality of oil used, temperature, duration of frying, and type of product and its composition (Figure 5.2.1.1). In the present study, with the increase in intermittent frying period greasiness significantly increased ($p<0.05$) in french fries fried in CSO was observed as compared to GNO (Plate 5.2.1.2). However, no significant difference was observed between the greasiness scores of french fries fried in CSO and GNO (Table 5.2.1.1).

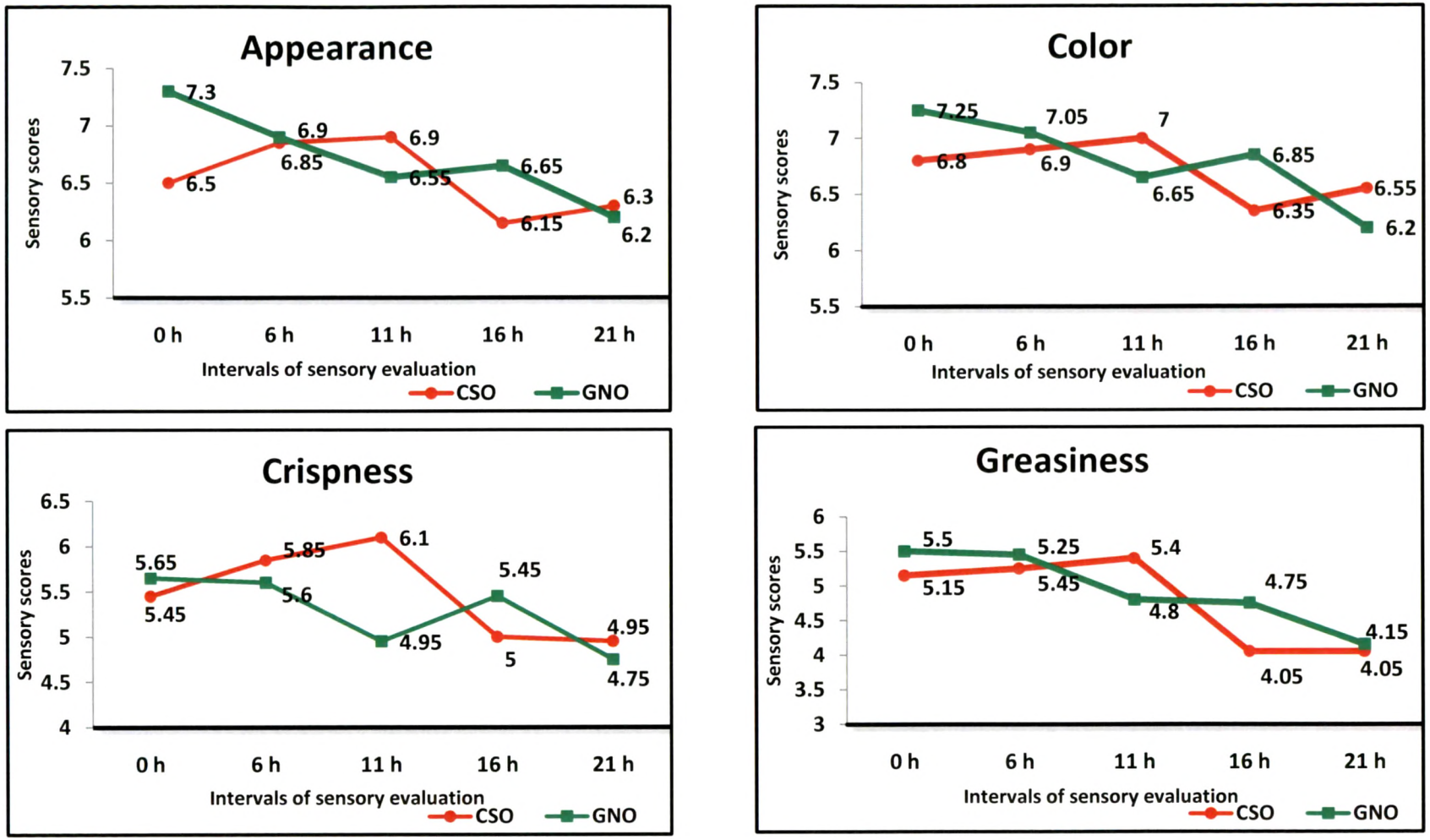


Figure 5.2.1.1: Mean sensory scores for appearance, color, crispness and greasiness of french fries fried in CSO and GNO at intermittent intervals

Plate 5.2.1.1: Panelists performing sensory evaluation

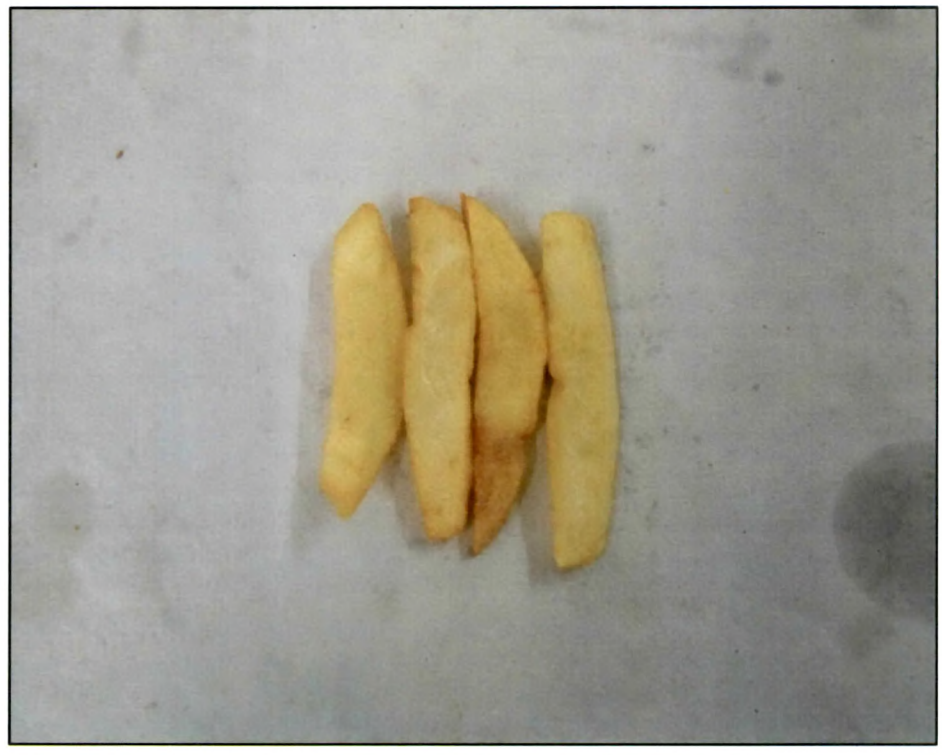


Plate 5.2.1.2: Puffiness/Absorption of oil in french fries at the end of 21 h of intermittent frying

Table 5.2.1.1: Mean sensory scores of french fries fried in CSO and GNO at intermittent duration of frying

Sensory Attributes	Oil	0 h	6 h	11 h	16 h	21 h	F-value
	CSO	6.5±1.4	6.8±1.1	6.9±0.85	6.1±1.4	6.3±1.2	1.4^{NS}
Appearance	GNO	7.3±1.1	6.9±1.2	6.5±1.4	6.6±0.93	6.2±1.4	2.1^{NS}
	't'	1.99^{NS}	0.13^{NS}	0.94^{NS}	1.27^{NS}	0.24^{NS}	
	CSO	6.8±1.4	6.9±0.97	7±0.92	6.3±1.3	6.5±1.1	1.03^{NS}
Color	GNO	7.2±1.0	7.0±1.0	6.6±1.5	6.8±0.93	6.2±1.3	2.28^{NS}
	't'	1.14^{NS}	0.5^{NS}	0.86^{NS}	1.39^{NS}	0.89^{NS}	
	CSO	5.4±1.4	5.8±1.8	6.1±1.3	5±1.7	4.9±1.7	1.91^{NS}
Crispness	GNO	5.6±1.7	5.6±1.4	4.9±1.6	5.4±1.7	4.7±1.5	1.21^{NS}
	't'	0.39^{NS}	0.48^{NS}	2.41^{*}	0.80^{NS}	0.37^{NS}	
	CSO	$5.1±1.4^{a}$	$5.2±1.5^{a}$	$5.4±1.6^{a}$	$4.0±1.7^{b}$	$4.0±1.6^{bc}$	3.59^{*}
Greasiness	GNO	5.5±1.8	5.4±1.3	4.8±1.5	4.7±1.5	4.1±1.7	2.42^{NS}
	't'	0.68^{NS}	0.44^{NS}	1.19^{NS}	1.36^{NS}	0.19^{NS}	
	CSO	$6.05±1.76^{a}$	$6.05±1.82^{a}$	$6.75±1.07^{ab}$	$5.2±2.09^{ac}$	$5.15±1.93^{ac}$	2.88^{*}
Flavor	GNO	$6.8±1.15^{a}$	$6.2±1.44^{ab}$	$5.6±2.01^{b}$	$5.9±1.33^{b}$	$5.45±1.39^{b}$	2.58^{*}
	't'	1.59^{NS}	0.29^{NS}	2.25^{*}	1.26^{NS}	0.56^{NS}	
	CSO	5.9±1.7	6.4±2.0	6.8±0.9	5.5±1.9	5.6±1.6	2.17^{NS}
Taste	GNO	6.9±1.3	6.3±1.4	5.7±1.8	6.2±1.6	5.7±1.5	2.05^{NS}
	't'	2.17^{*}	0.18^{NS}	2.46^{*}	1.24^{NS}	0.29^{NS}	
	CSO	$6.3±1.0^{a}$	$6.6±1.2^{ad}$	$6.6±1.0^{ad}$	$5.5±1.5^{bc}$	$5.1±1.3^{b}$	6.00^{**}
Odor	GNO	$7.0±1.0^{a}$	$6.8±1.3^{a}$	$6.5±1.4^{ac}$	$5.9±1.1^{bc}$	$5.2±1.4^{b}$	6.59^{***}
	't'	2.17^{*}	0.37^{NS}	0.25^{NS}	0.91^{NS}	0.23^{NS}	
Overall	CSO	$6.0±1.3^{a}$	$6.4±1.5^{a}$	$7±0.79^{b}$	$5.6±1.7^{a}$	$5.6±1.6^{a}$	3.12^{*}
acceptability	GNO	$6.8±1.0^{a}$	$6.6±1.3^{ab}$	$5.85±1.8^{b}$	$5.9±1.3^{b}$	$5.7±1.4^{b}$	2.47^{*}
	't'	2.06^{*}	0.44^{NS}	2.53^{*}	0.64^{NS}	0.20^{NS}	

Note: 1. h-hours; 2. *- significant at p<0.05, ** - significant at p<0.01, ***- significant at p<0.001, NS- not significant; 3. Indicators for sensory scores from 9-1 (9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4- dislike slightly, 3-dislike moderately, 2-dislike very much, 1-dislike extremely) ; 4. Dissimilar superscripts in each row between the columns indicate significant differences amongst the values

Flavor, taste and odor scores of french fries are shown in Figure 5.2.1.2, 5.2.1.3 and 5.2.1.4 respectively. Mean flavor scores (F-test) of french fries prepared in both the oils showed significant reduction ($p<0.05$) as the duration of frying increased. However, student 't' test showed significant higher ($p<0.05$) score of french fries fried in CSO as compared to GNO (Table 5.2.1.1).

With respect to taste, french fries fried in GNO were more preferred than CSO prepared fries up to 6 h of intermittent frying duration. However, at 11 h interval, taste scores for french fries fried in CSO were significantly higher ($p<0.05$) than GNO fried fries and thereafter the taste scores reduced in both the oils (Table 5.2.1.1).

A peculiar/different strong nutty odor of GNO was noticed during the initial hours of frying (up to 4 h of intermittent frying). However, as the duration of intermittent frying increased from 0 to 21 h the odor scores of both GNO and CSO fried french fries decreased significantly ($p<0.001$) shown in Table 5.2.1.1. Between the GNO and CSO fried french fries significant ($p<0.05$) difference were seen only at 0 h.

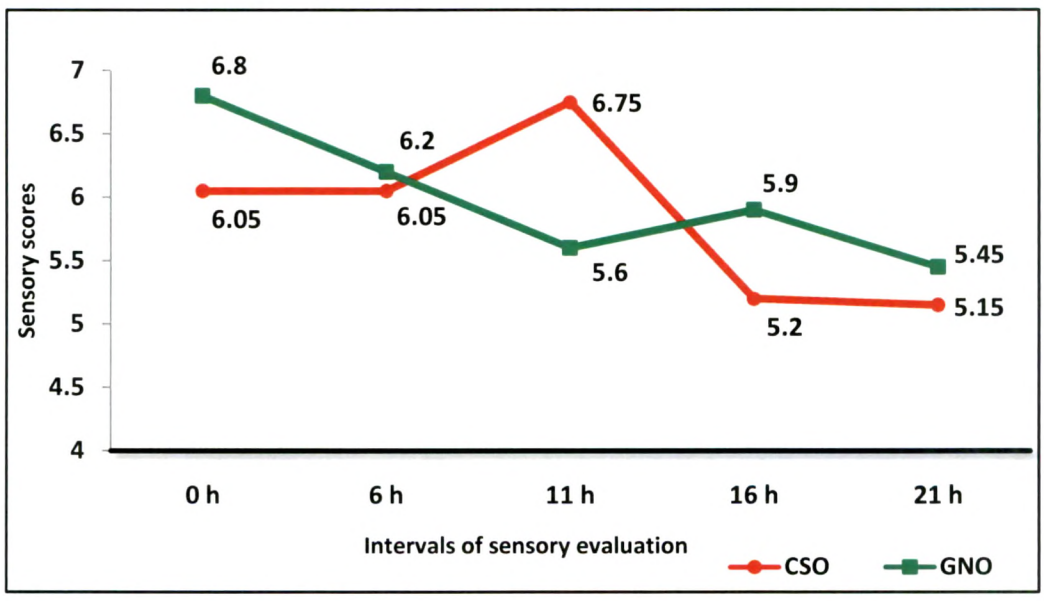


Figure 5.2.1.2: Mean sensory scores for flavor of french fries fried in CSO and GNO at intermittent intervals

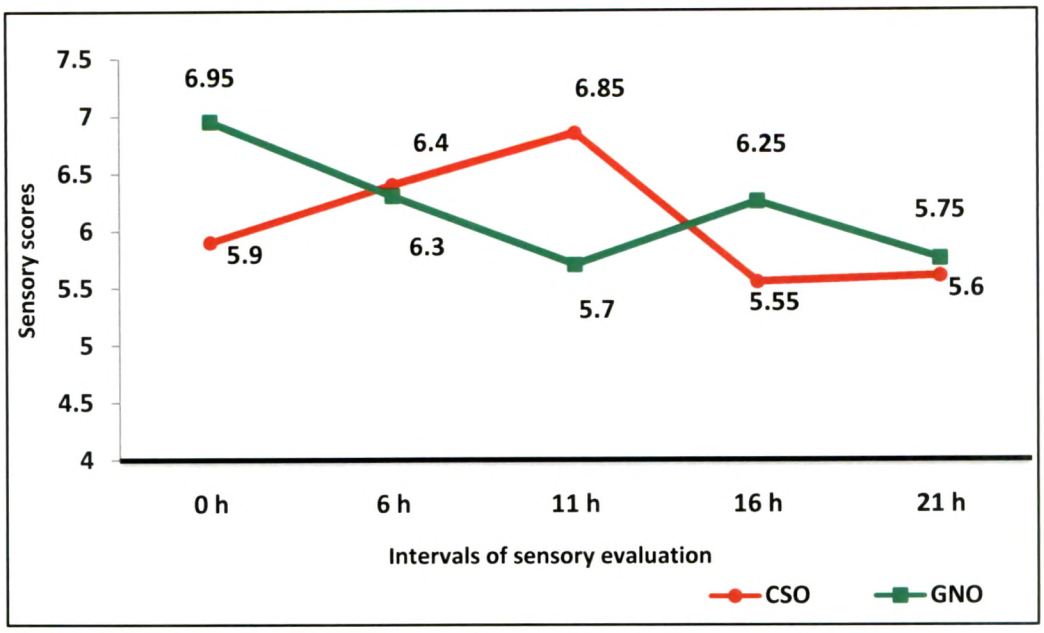


Figure 5.2.1.3: Mean sensory scores for taste of french fries fried in CSO and GNO at intermittent intervals

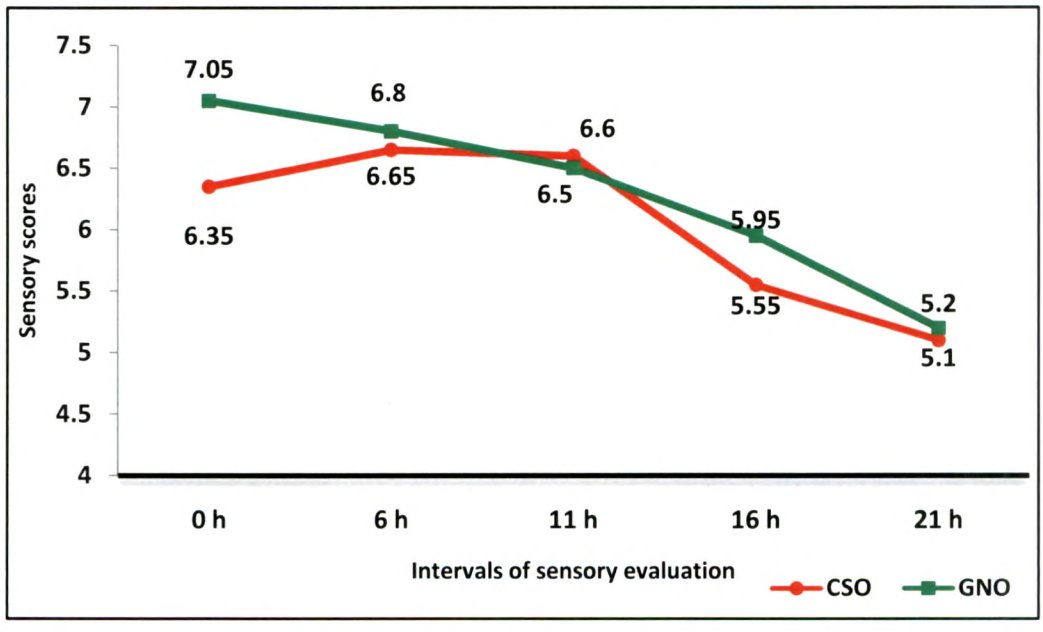


Figure 5.2.1.4: Mean sensory scores for odor of french fries fried in CSO and GNO at intermittent intervals

The overall acceptability mean scores of french fries fried in CSO and GNO is shown in Figure 5.2.1.5. At first hour of frying, the mean scores for overall acceptability of french fries prepared in GNO showed significantly higher ($p<0.05$) than those fried in CSO. However, at 11 h of frying overall acceptability of CSO fried french fries scores were significantly higher ($p<0.05$) than GNO fried fries as there score may have been influenced by the flavor scores.

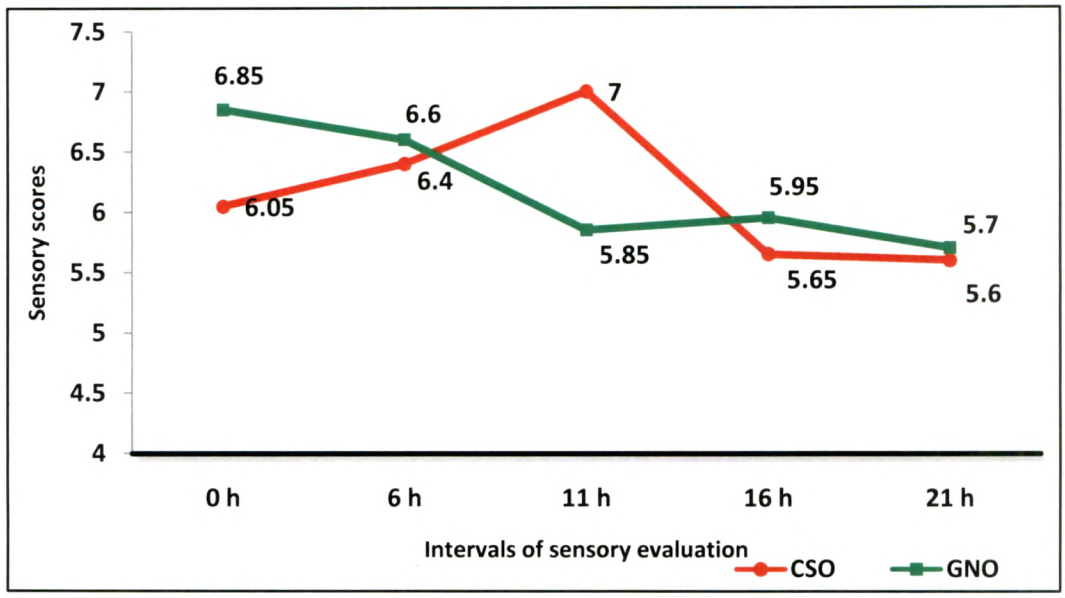


Figure 5.2.1.5: Mean sensory scores for overall acceptability of french fries fried in CSO and GNO at intermittent intervals

The flavor of food comprises three components- odor, taste and mouth feel. Therefore relation of flavor with these sensory attributes was investigated. Table 5.2.1.2 shows the strong relation of flavor with odor, taste and greasiness of french fries fried in CSO and GNO.

Pearson's correlation coefficient test reveal a strong relationship between the flavor scores and overall acceptability scores of french fries r=0.96 (CSO and GNO).

Table 5.2.1.2: Correlation coefficient of flavor with odor, greasiness, overall acceptability and taste scores of french fries fried in CSO and GNO oil at intermittent intervals

Attribute	Type of oil	
	CSO	GNO
	*Correlation coefficient (r)	
Flavor-odor	0.89	0.79
Flavor-greasiness	0.95	0.88
Flavor-overall acceptability	0.96	0.96
Flavor-taste	0.93	0.97

Note- *significant at $p<0.05$

5.2.2: Sensory quality of bhajias fried in CSO and GNO at intermittent durations

Bhajias fried in CSO and GNO at intermittent intervals were assessed for various sensory qualities like appearance, color, crispness, greasiness, flavor, taste, odor and overall acceptability.

Mean scores for appearance and color of bhajias are graphically shown in Figure 5.2.2.1 and 5.2.2.2 respectively. F-test revealed no significant difference in the mean scores for appearance and color of bhajias fried in both CSO and GNO as the period of intermittent frying increased from 0 h to 21 h. Also no significant difference was seen between CSO and GNO for appearance and color of bhajias (Table 5.2.2.1).

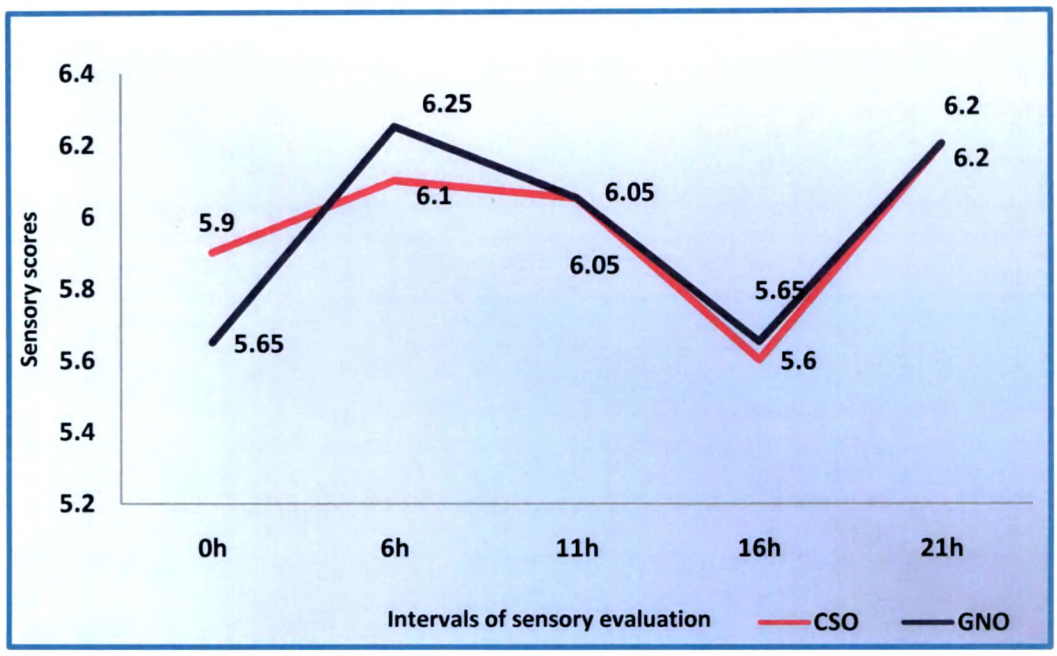


Figure 5.2.2.1: Mean sensory scores for appearance of bhajias fried in CSO and GNO at intermittent intervals

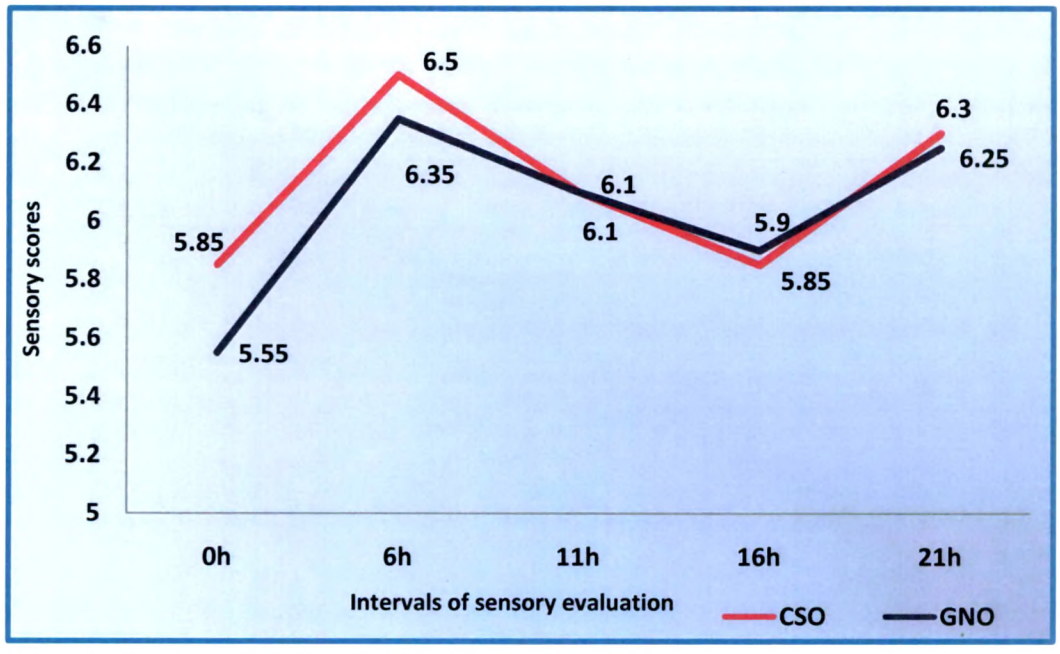


Figure 5.2.2.2: Mean sensory scores for color of bhajias fried in CSO and GNO at intermittent intervals

Table 5.2.2.1: Mean sensory scores of bhajias fried in CSO and GNO at intermittent duration of frying

Sensory Attributes	Oil	0 h	6 h	11 h	16 h	21 h	F-value
Appearance	CSO	5.9±1.71	6.1±1.21	6.05±1.28	5.6±1.14	6.2±1.54	0.56^{NS}
	GNO	5.65±1.60	6.25±0.85	6.05±1.28	5.65±1.39	6.2±1.61	0.91^{NS}
	't'	0.47 ^{NS}	0.45 ^{NS}	0 ^{NS}	0.12 ^{NS}	0 ^{NS}	
Color	CSO	5.85±1.53	6.5±1.05	6.1±1.45	5.85±1.23	6.3±1.38	0.90^{NS}
	GNO	5.55±1.54	6.35±1.39	6.1±1.37	5.9±1.37	6.25±1.37	1.01^{NS}
	't'	0.62 ^{NS}	0.39 ^{NS}	0 ^{NS}	0.12 ^{NS}	0.11 ^{NS}	
Crispness	CSO	5.45±1.67	5.55±1.73	5.55±1.39	5.25±1.55	6.05±1.43	0.71^{NS}
	GNO	5.1±1.71	5.35±1.50	5.6±1.43	5.15±1.50	5.6±1.47	0.49^{NS}
	't'	0.65 ^{NS}	0.39 ^{NS}	0.11 ^{NS}	0.21 ^{NS}	0.98 ^{NS}	
Greasiness	CSO	5.1±1.33	5.3±1.38	4.6±1.35	4.0±1.56	4.7±1.95	2.16^{NS}
	GNO	4.9±1.37	5.15±1.39	4.5±1.73	4.05±1.76	4.35±2.06	1.36^{NS}
	't'	0.47 ^{NS}	0.34 ^{NS}	0.20 ^{NS}	0.09 ^{NS}	0.55 ^{NS}	
Flavor	CSO	5.9±1.97	6.45±1.28	5.85±1.46	5.4±1.39	5.4±1.85	1.45^{NS}
	GNO	5.0±1.65	5.5±1.70	5.1±1.33	4.9±1.29	5.35±1.42	0.56^{NS}
	't'	1.56 ^{NS}	1.20 ^{NS}	1.70 ^{NS}	1.18 ^{NS}	0.10 ^{NS}	
Taste	CSO	6.2±1.88	6.5±1.40	6.0±1.45	5.55±1.43	5.5±2.09	1.30^{NS}
	GNO	5.15±1.57	5.6±1.54	5.05±1.23	4.75±1.12	5.65±1.04	1.68^{NS}
	't'	1.92 ^{NS}	1.94 ^{NS}	2.23*	1.97 ^{NS}	0.29 ^{NS}	
Odor	CSO	6.1±1.83	6.15±1.14	5.65±1.53	6.05±1.05	5.35±1.84	1.05^{NS}
	GNO	4.95±1.90	5.7±0.86	5.1±0.91	4.9±1.45	5.55±1.36	1.44^{NS}
	't'	1.95 ^{NS}	1.41 ^{NS}	1.38 ^{NS}	2.88**	0.34 ^{NS}	
Overall acceptability	CSO	5.9±1.80	6.5±1.10	6.0±1.49	5.45±1.43	5.45±1.96	1.53^{NS}
	GNO	5.2±1.36	5.5±1.36	5.25±1.37	5.15±1.35	5.6±1.54	0.40^{NS}
	't'	1.39 ^{NS}	2.56*	1.66 ^{NS}	0.68 ^{NS}	0.27 ^{NS}	

Note: 1. h-hours; 2. *- significant at p<0.05, ** - significant at p<0.01, ***- significant at p<0.001, NS- not significant; 3. Indicators for sensory scores from 9-1 (9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4- dislike slightly, 3-dislike moderately, 2-dislike very much, 1-dislike extremely)

Plate 5.2.2.1 shows the appearance of bhajias fried in CSO at initial hour of intermittent frying and Plate 5.2.2.2 depict the change in appearance of bhajias at 25 h of intermittent frying in the same oil.

Plate 5.2.2.1: Appearance of bhajias fried in CSO at initial hours of frying

Plate 5.2.2.2: Change in appearance of bhajias fried in CSO at the end of frying hours

At the initial hours bhajias fried in CSO showed better scores for crispness as compared to bhajias fried in GNO (Figure 5.2.2.3). However, the crispness scores of bhajias fried in CSO increased at the end of intermittent frying as compared to bhajias fried in GNO but this increase was not statistical significant (Table 5.2.2.1).

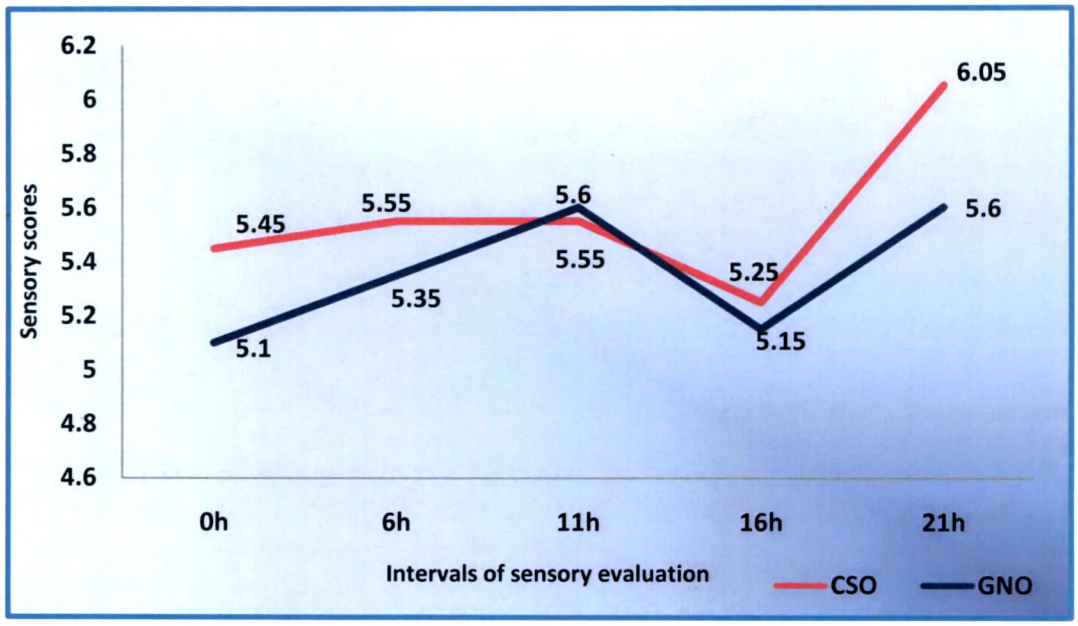


Figure 5.2.2.3: Mean sensory scores for crispness of bhajias fried in CSO and GNO at intermittent intervals

Greasiness scores (Figure 5.2.2.4) of bhajias fried in CSO and GNO slightly decreased up to 21 h of intermittent frying, representing more oil absorption as the duration of frying increased. Greasiness scores of bhajias fried in cottonseed oil were higher as compared to bhajias fried in groundnut oil. Table 5.2.2.1 showed no statistical difference in between the intermittent frying intervals of bhajias (ANOVA) and between the sensory scores of bhajias fried in two different oils (CSO and GNO) ('t').

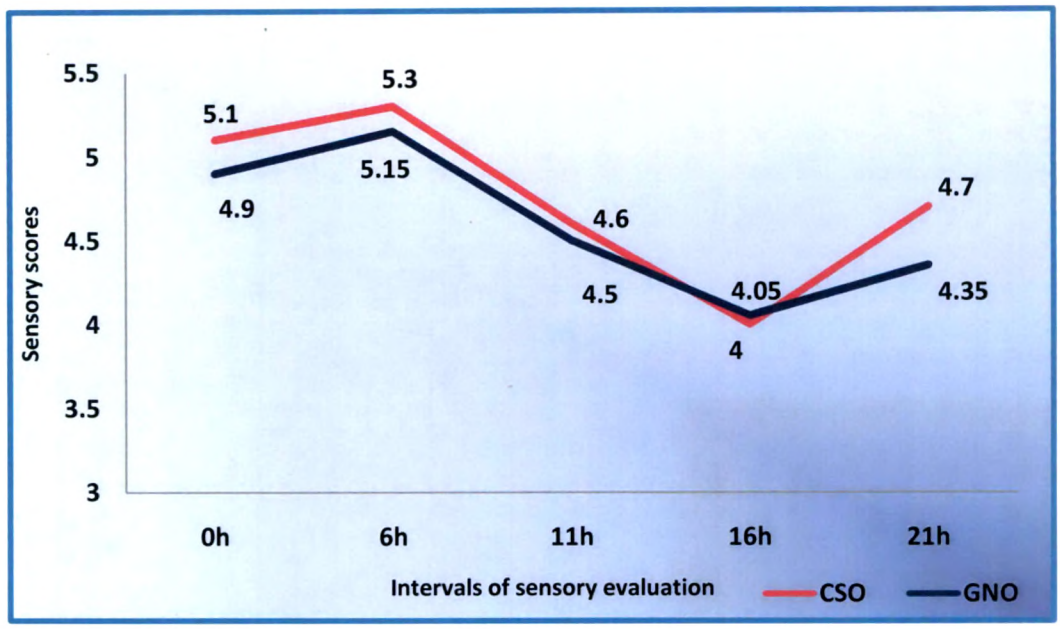


Figure 5.2.2.4: **Mean sensory scores for greasiness of bhajias fried in CSO and GNO at intermittent intervals**

Mean flavor scores of bhajias fried in CSO and GNO are shown in Figure 5.2.2.5. These scores increased up to 6 h of intermittent frying, thereafter, they decreased slightly. The reduction in flavor scores for both the oils was not statistically significant.

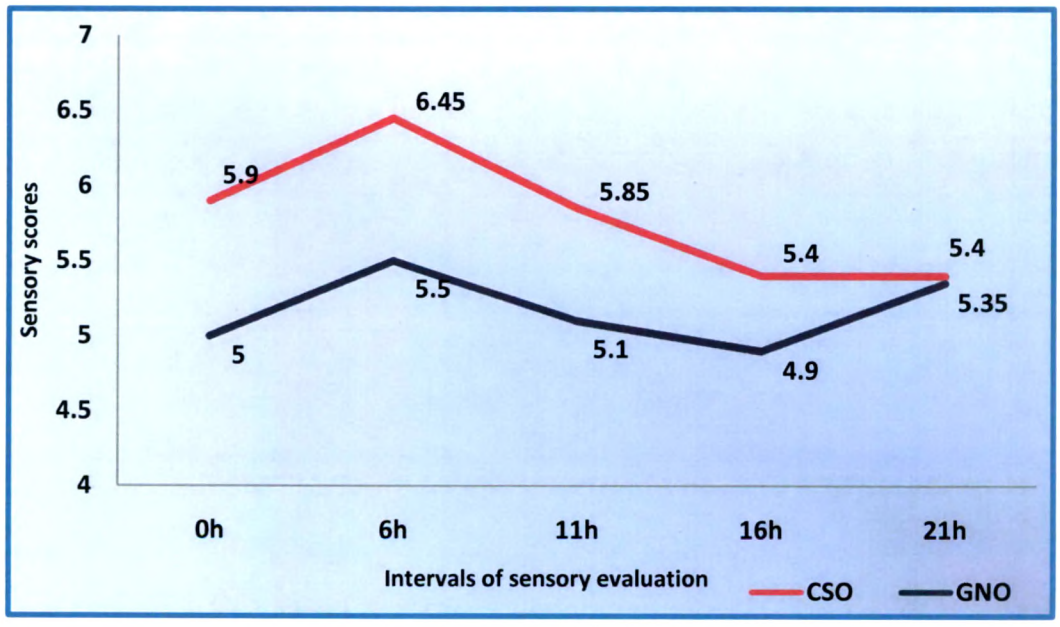


Figure 5.2.2.5: **Mean sensory scores for flavor of bhajias fried in CSO and GNO at intermittent intervals**

Mean scores for taste of bhajias can be seen in Figure 5.2.2.6. Mean taste scores of bhajias prepared in CSO and GNO; also showed similar pattern like overall acceptability of bhajias. Mean sensory scores for taste of bhajias fried in CSO were higher than those fried in GNO. ANOVA revealed no significant difference between sensory scores of bhajias fried in two oils (Table 5.2.2.1).

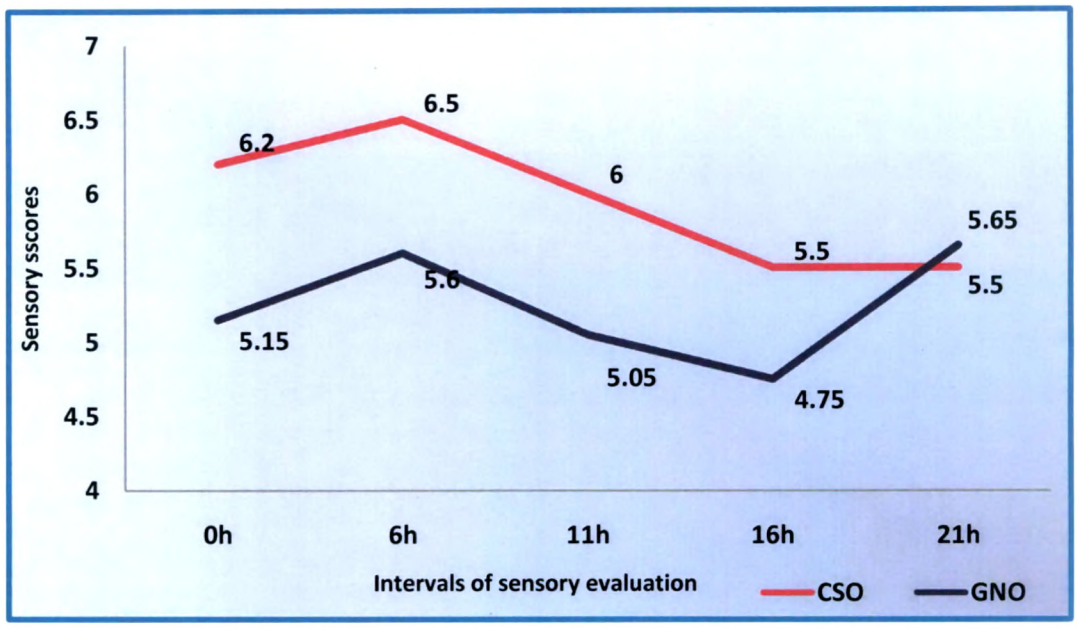


Figure 5.2.2.6: Mean sensory scores for taste of bhajias fried in CSO and GNO at intermittent intervals

Bhajias prepared in CSO scored higher odor scores at initial hours of frying as compared to bhajias fried in GNO shown in Figure 5.2.2.7. The odor scores of bhajias fried in GNO significantly remained low during intermittent frying up to 16 h when compared to bhajias fried in CSO. However, this difference was not statistically significant up to 11 h of intermittent frying. And at 16 h of intermittent frying the odor scores of GNO fried bhajias reduced significantly (Table 5.2.2.1).

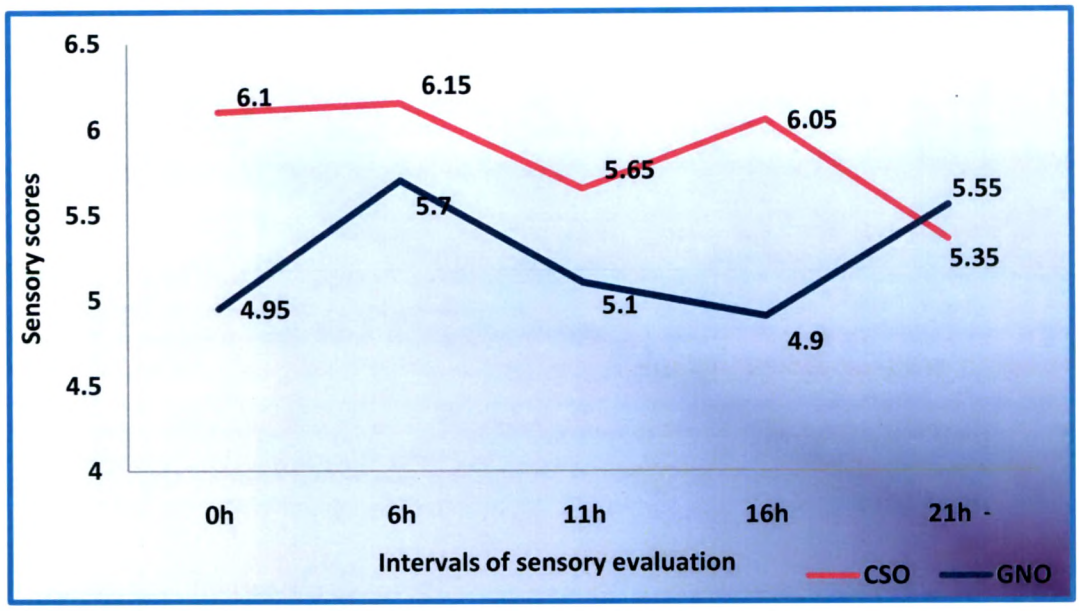


Figure 5.2.2.7: Mean sensory scores for odor of bhajias fried in CSO and GNO at intermittent intervals

Overall acceptability of bhajias fried in both the oils showed decrease in sensory mean scores during the 21 h of intermittent frying (Figure 5.2.2.8). ANOVA (F-test) showed non-significant difference in the overall acceptability scores of bhajias as the duration of intermittent frying increased from 0 to 21 h. However, at 6 h CSO fried bhajias showed significantly ($p<0.05$) higher overall acceptability scores than those fried in GNO (Table 5.2.2.1).

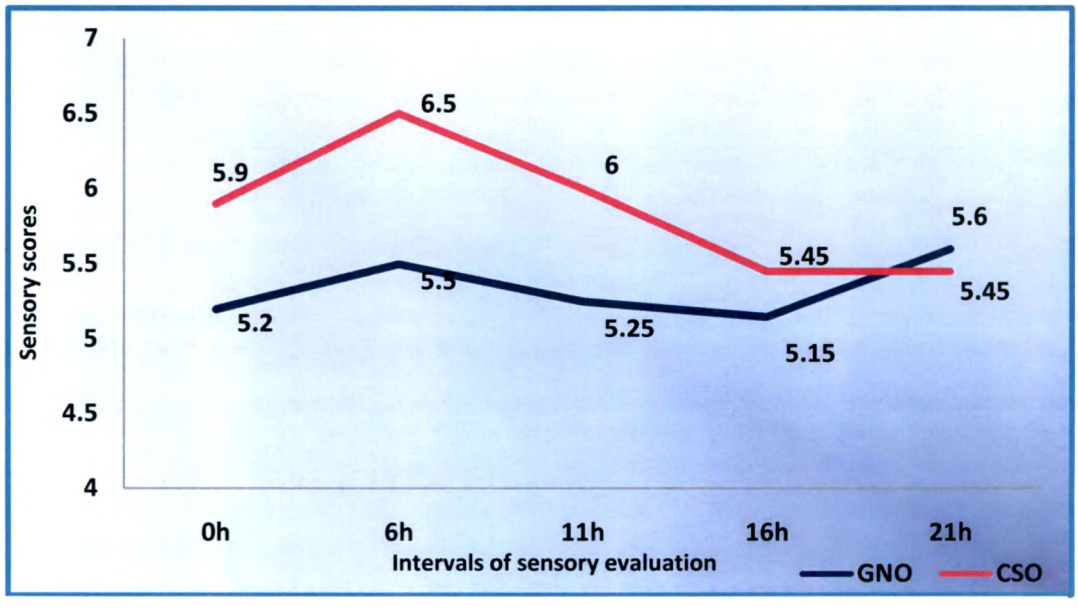


Figure 5.2.2.8: Mean sensory scores for overall acceptability of bhajias fried in CSO and GNO at intermittent intervals

Table 5.2.2.2 shows strong relation of flavor with odor, taste and greasiness of bhajias fried in CSO and GNO. Pearson's correlation coefficient test revealed a strong relationship between the flavor scores and overall acceptability scores of bhajias r=0.99 and 0.91 in CSO and GNO respectively.

Table 5.2.2.2: Correlation coefficient of flavor with odor, greasiness scores and overall acceptability of bhajias fried in CSO and GNO at intermittent intervals

Attribute	Type of oil	
	CSO	GNO
	*Correlation coefficient (r)	
Flavor-odor	0.55	0.99
Flavor-greasiness	0.80	0.55
Flavor-overall acceptability	0.99	0.91
Flavor-taste	0.97	0.93

Note- *significant at $p<0.05$

5.2.3: Comparison of sensory mean scores of non-coated (french fries) and batter coated (bhajias) potatoes fried in CSO and GNO

Figure 5.2.3.1 and 5.2.3.2 show the difference in sensory scores of non-coated and coated potatoes fried in CSO at intermittent intervals. Appearance, flavor, taste, odor and overall acceptability of non-coated potatoes were significantly higher ($p<0.05$) at 11 h interval than batter coated potatoes fried in CSO. Crispness of batter coated potatoes was significantly higher ($p<0.05$) than non-coated potatoes at the end (21 h) of intermittent frying hours.

Sensory scores of GNO fried non-coated and coated potatoes are shown in Figure 5.2.3.3 and 5.2.3.4. At different intervals of frying non-coated potatoes fried in GNO showed significant higher ($p<0.001$) scores for appearance, flavor, taste, odor and overall acceptability than batter coated potatoes. However, crispness and greasiness scores of both coated and non-coated potatoes did not show any significant difference at any hour of intermittent frying.

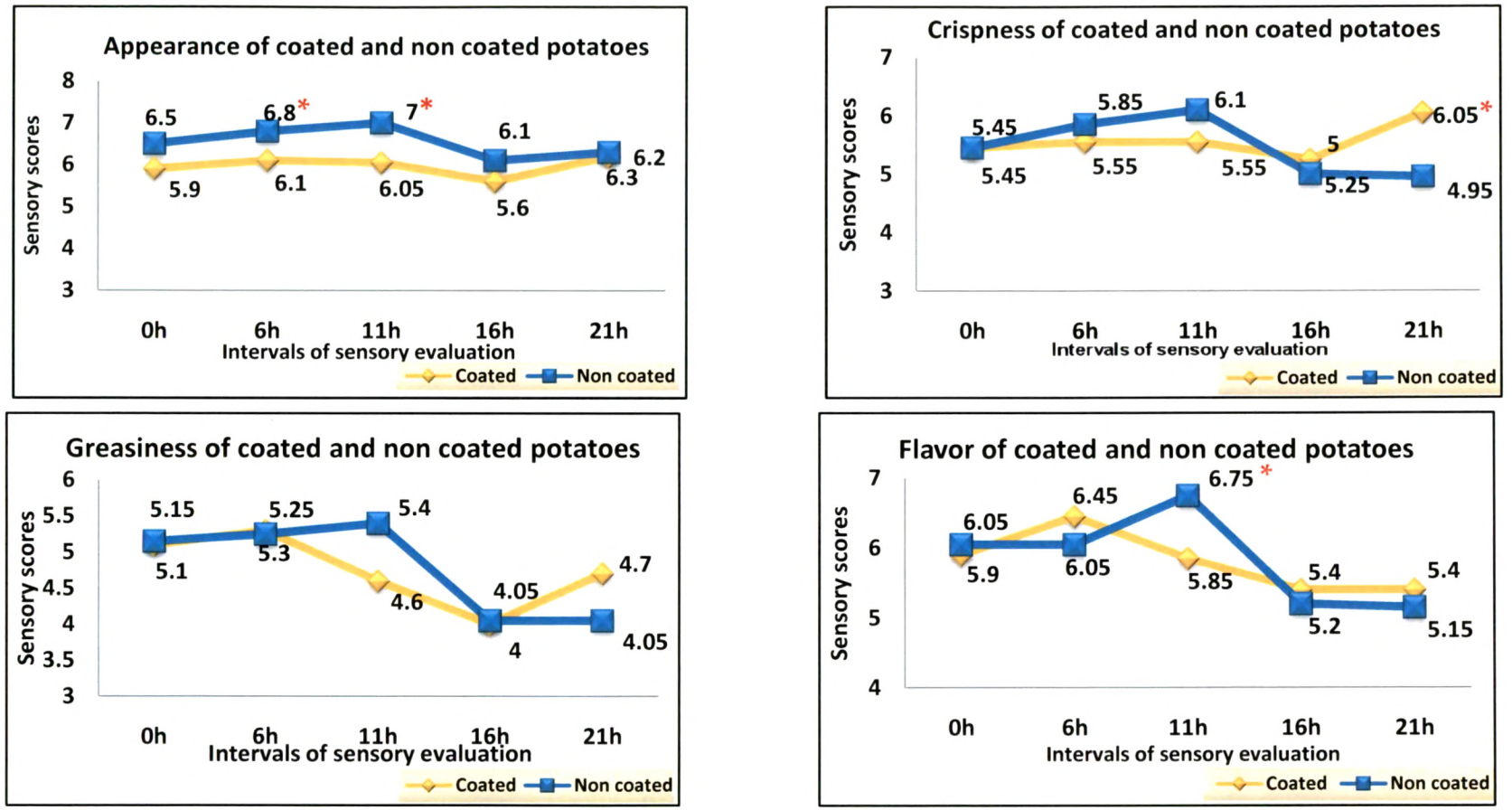
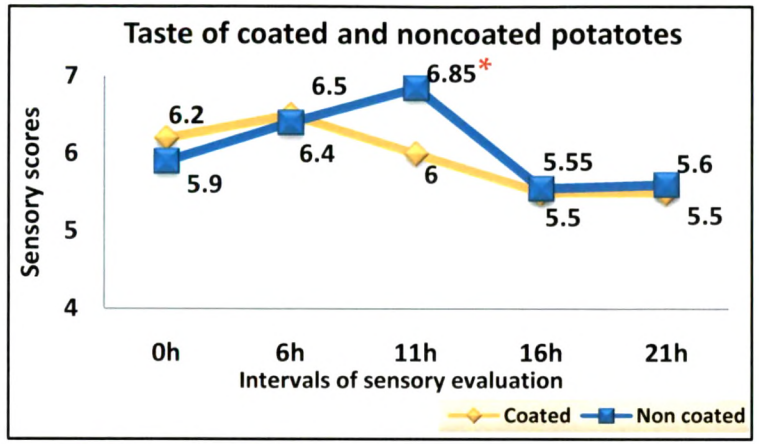
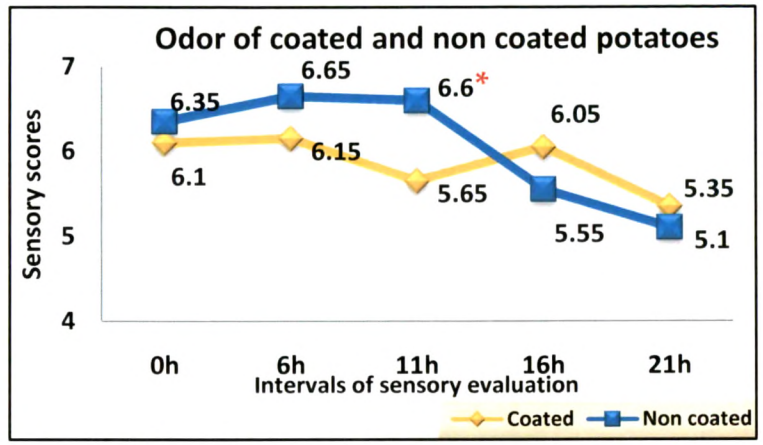


Figure 5.2.3.1: Comparison of sensory mean scores of coated and non coated potatoes fried in CSO at intermittent intervals

Note- *-significant at $p<0.05$





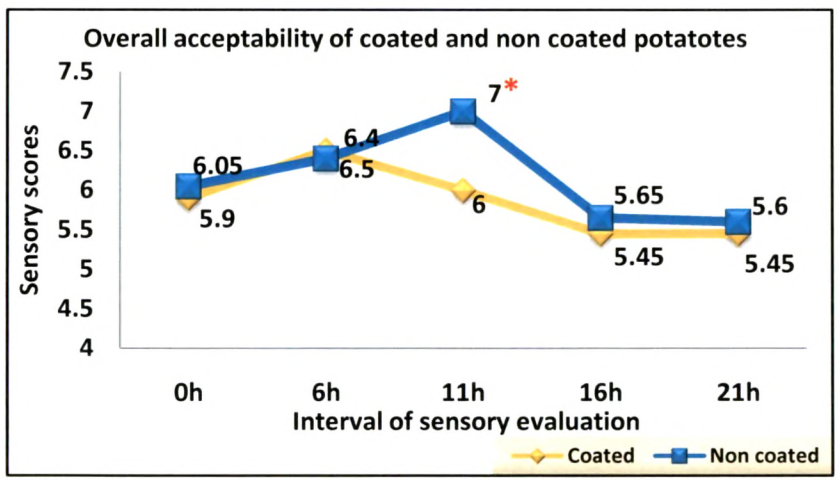


Figure 5.2.3.2: Comparison of sensory mean scores of coated and non coated potatoes fried in CSO at intermittent intervals

Note- *-significant at $p<0.05$

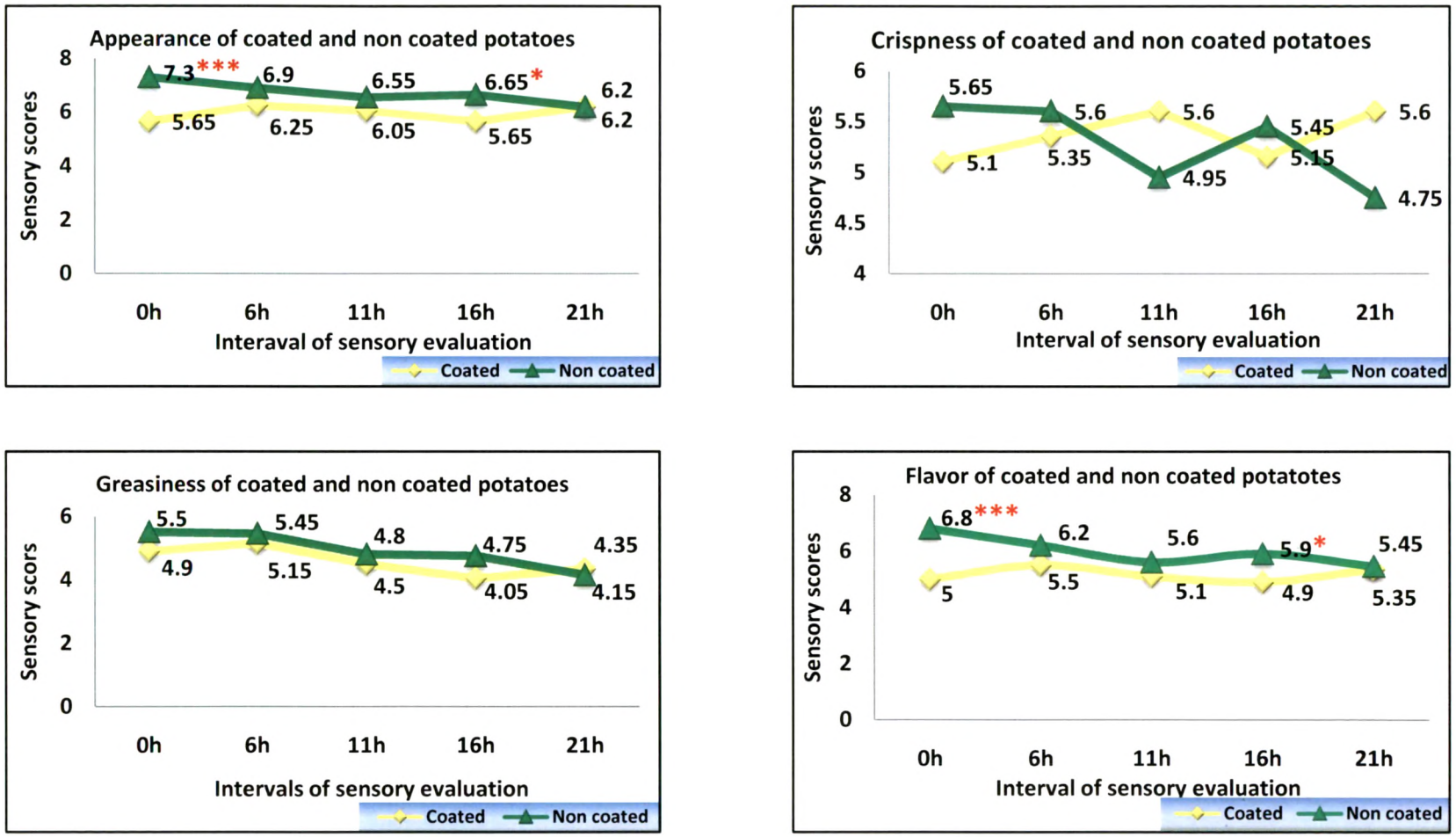


Figure 5.2.3.3: Comparison of sensory mean scores of coated and non coated potatoes fried in GNO at intermittent intervals

Note- *-significant at p<0.05; ***-significant at p<0.001

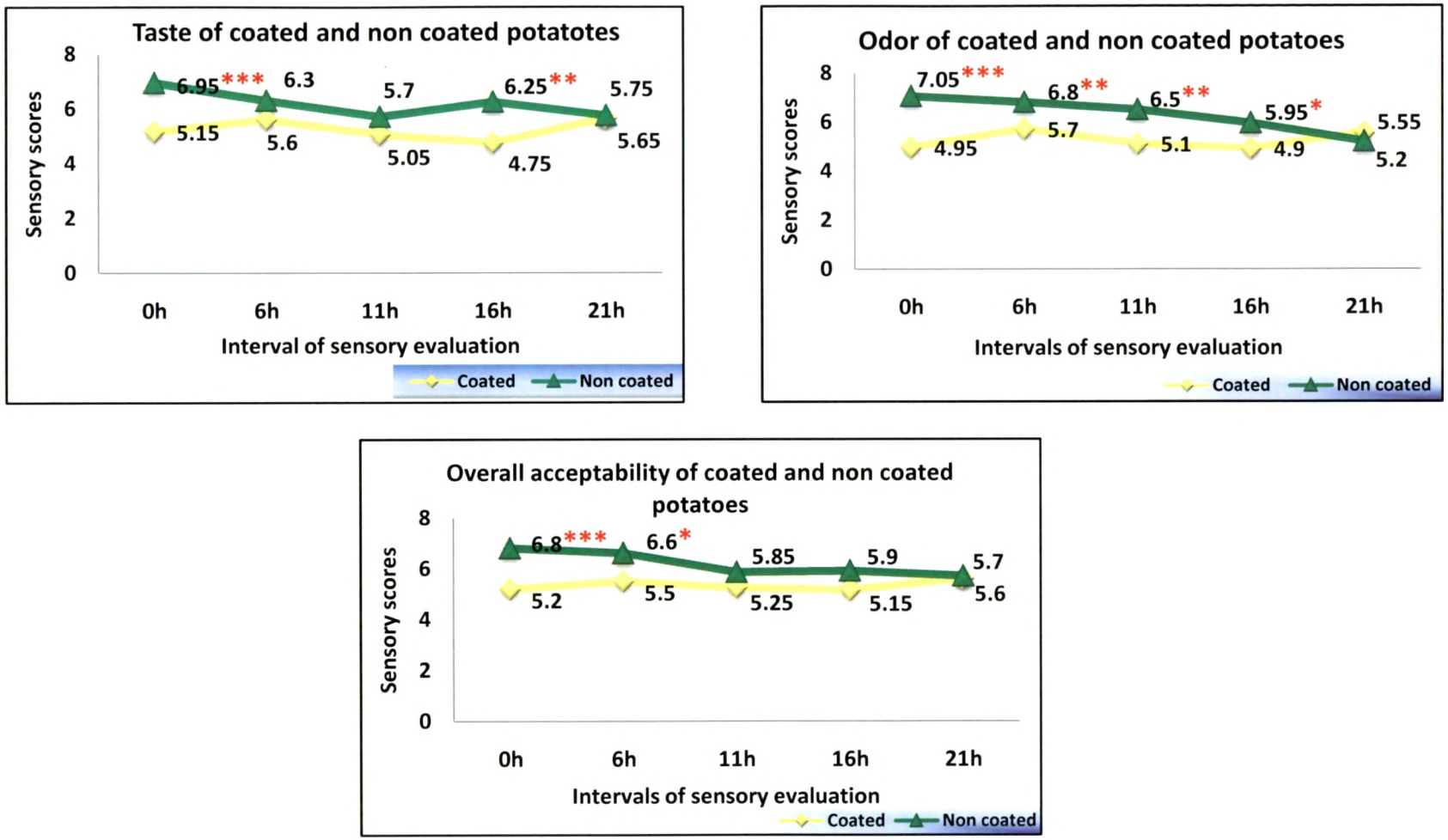


Figure 5.2.3.4: Comparison of sensory mean scores of coated and non coated potatoes fried in GNO at intermittent intervals

Note- *-significant at p<0.05; **-significant at p<0.01; ***-significant at p<0.001

5.2.4: Oil uptake by french fries and bhajias fried in CSO and GNO up to 25 h of intermittent frying.

Frying of food product results in evaporation of water present in raw material and this place is partially replaced by oil consequently influencing the properties of final product. Oil uptake by french fries and bhajias fried in CSO and GNO up to 25 h of intermittent frying is shown in Table 5.2.4.1 and 5.2.4.2.

Between the fried products, intermittent frying of bhajias showed higher oil uptake as compared to french fries. Under the similar frying conditions, oil uptake of GNO used for bhajias and french fries was 19.5% and 12% respectively. Whereas CSO oil uptake was 15.6% and 11.5% for bhajias and french fries respectively.

Table 5.2.4.1: Total oil used after 25 h of intermittent french fries frying

Oil	Initial level of oil used for frying	Total oil removed for chemical analysis	Actual amount of oil used for frying	Amount of oil left after 25 h of intermittent frying	Amount of oil absorbed (mean) for 25 batches of frying	Amount of oil used /batch for 90g french fries	% Oil uptake
CSO	1500	300	1200	940	260	10.4	11.5%
GNO	1500	300	1200	930	270	10.8	12%

Table 5.2.4.2: Total oil used up to 25 h of intermittent bhajias frying

Oil	Initial level of oil used for frying	Total oil removed for chemical analysis	Actual amount of oil used for frying	Amount of oil left after 25 h of intermittent frying	Amount of oil absorbed (mean) for 25 batches of frying	Amount of oil used /batch for 200g bhajias	% Oil uptake
CSO	1354	280	1074	293.8	780.2	31.2	15.6%
GNO	1348	280	1068	84.6	983.4	39.3	19.5%

PHASE II- RESULT HIGHLIGHTS

French fries

- *Intermittent frying of french fries in CSO and GNO showed a non significant change for appearance, color, crispness, greasiness and taste scores.*
- *Flavor, odor and overall acceptability scores showed a significant reduction ($p<0.05$) with the increase in frying hours up to 21 h of intermittent frying.*
- *Taste, odor and overall acceptability of GNO fried french fries had significantly higher ($p<0.05$) scores than french fries fried in CSO at initial hour (0 h) of frying.*
- *At 11 h of intermittent frying french fries fried in CSO showed significantly higher ($p<0.05$) sensory scores for crispness, taste, flavor and overall acceptability than those fried in GNO.*
- *After 11 h of intermittent frying, the flavor, odor and overall acceptability of both CSO and GNO fried fries deteriorated with no significant difference between scores of french fries fried in both the studied oils.*

Bhajias

- *Bhajias fried in both CSO and GNO showed non significant change in sensory attributes during the intermittent frying up to 21 h.*
- *The crispness scores of bhajias improved as the duration of frying increased in both the oils.*
- *CSO fried bhajias scored higher up to 11 h of frying than GNO fried bhajias; afterward no changes in sensory attributes were observed in the oils.*

Comparison between sensory scores of french fries and bhajias (non-coated vs. batter coated) fried in CSO and GNO at intermittent intervals

- *At 0 h frying, french fries fried in GNO showed significantly higher ($p<0.05$) scores for appearance, flavor, taste, odor and overall acceptability than bhajias.*
- *At 11 h of intermittent frying significantly higher ($p<0.05$) scores for appearance, flavor, taste, odor and overall acceptability of CSO fried french fries were observed than those fried in GNO.*
- *Bhajias fried in CSO showed significantly higher ($p<0.05$) scores for crispness than GNO fried bhajias at the end (21 h) of intermittent frying.*
- *Odor of GNO fried french fries were more acceptable up to 16 h of intermittent frying than bhajias fried in CSO.*

DISCUSSION

Deep-fat fried products, prepared from raw vegetables, cereals, legumes and their blends, are universally popular due to their desirable organoleptic profile (Annapure US, Singhal RS and Kulkarni PR, 1998). Frying oil acts as a heat transfer medium and contributes to the texture and flavor of fried food. Foods fried at the optimum temperature and time have golden brown color, are properly cooked, and crispy, and have optimal oil absorption (Blumenthal MM, 1991; Dobarganes C, Márquez-Ruiz G, and Velasco J, 2000).

Present phase of the study was undertaken to evaluate french fries and bhajias at intermittent intervals of frying.

The sensory qualities of french fries revealed no significant difference in the mean scores for appearance, color, crispness and taste of french fries fried in CSO (cottonseed oil) and GNO (groundnut oil) at the end of 21 h of intermittent frying. A study by Nor FM et al (2009) also reported non significant change in color, oiliness and crispness between samples when french fries were intermittently fried for 5 days at 180^0 C temperature in oil containing BHT (Butylated Hydroxy Toluene) and *Curcuma longa* (turmeric) extract.

The crispness of fried foods is greatly influenced by several factors like temperature, oil uptake and number of frying. Reduction in crispness scores of french fries fried in both the oils was observed as the duration of frying increased. However, at 11 h of intermittent frying, crispness of french fries prepared in CSO had significantly higher scores than those prepared in GNO. Another study showed significant decrease in crispness of potato chips during frying in low linolenic canola oil than sunflower and palm olein oil (Xu XQ et al, 1999). In the present study, higher crispness of french fries fried in CSO possibly be due to its high linolenic acid (0.34g/100g) than GNO containing only 0.21g/100g linolenic acid.

Taste of fried foods is influenced by several factors such as product fried, temperature including type of oil used and its fatty acid profile. Present study

showed that at initial hours french fries fried in GNO were more acceptable due to its peculiar/different taste. Use of groundnut oil is high in Gujarat region could be the reason for more acceptability of french fries fried in GNO. When french fries were intermittently fried in GNO initially acceptable taste subsided and french fries prepared in CSO were more liked by the panelist. These results could be influenced by the alteration in fatty acid profile i.e. increase in oleic acid and decrease in linoleic acid of fried oil. Similar results were observed when potato chips fried in medium-high-oleic sunflower oil as compared to potato chips fried in high-linolenic canola oil (Xu XQ et al, 1999).

Present study, showed a significant ($p<0.05$) reduction in flavor intensity of french fries fried in CSO and GNO as the period of frying increased. Fried food flavor is partly derived from the formation of 2, 4-decadienal during the thermal oxidation of linoleic acid (Choe E and Min DB, 2007). Results of the present study are in accordance with the studies stating that fried food flavor of fries generally decreases as the percentage of oleic acid increases and percent linoleic acid decreases in the frying oil (Narasimhamurthy K, and Raina PL, 1998). This result probably justifies that in CSO fried french fries, at 11 h of frying desirable fatty acid profile must be at its optimum level required for good taste of fried product. In a study by Warner K, Orr P and Glynn M (1997) showed when potato chips fried in CSO having the rate of 16% oleic/55% linoleic acid had significantly higher intensity of fried food flavor than potato chips fried in the oil with either 63% oleic/23% linoleic acid or 78% oleic/12% linoleic acid.

Studies described that typical desirable fried flavor is produced at the optimal concentration of oxygen. Low amounts of oxygen produce poor and weak flavor, and high levels of oxygen produce off-flavor. Fried flavor compounds in fried foods are mainly volatile compounds formed from linoleic acid and are dienal, alkenals, lactones, hydrocarbons, and various cyclic compounds (Pokorny J, 1989; Choe M and Min DB, 2007). In the present study off flavor developed in the french fries at the end of 20 and 21 h of frying; as reported

by sensory panelists could be due to development of other aldehydes such as nonanal, heptanal etc. as result of repeated frying (Tompkins C and Perkins EG, 1999; Warner K and Moser J, 2009).

Regards to odor it has been found that high oleic oils are more stable and produce less hexanal compounds (odor giving volatile compounds) than linoleic and linolenic rich oils (Warner K and Gupta M, 2005). Apparently, similar results were found in the present study which shows odor of groundnut oil fried french fries was notably higher than french fries fried in cottonseed oil. In another study, *pooris* fried in groundnut and coconut oil blend were more acceptable than those fried in palmolien and rice bran oil blend. This may be due to familiarity of the target groups with groundnut oil and absence of any dominant odor note of coconut oil (Raj PN, Prakash M and Bhat KK, 2006). As stated above in the present study also, because of continued culinary use of groundnut oil, sensory panelists may perhaps have developed a liking the products fried in GNO for its odor and flavor.

With respect to overall acceptability of french fries, high acceptability of CSO fried fries especially peaking at 11 h could possibly be due formation of 2, 4-decadienal which is considered as desired compound during frying of oil rich in linoleic acid (Warner K, Orr P and Glynn M, 1997). Study conducted by Xin XQ et al (1999) on six different oils showed, when potato chips were fried at 190^{0}C for 80 h intermittently in partially hydrogenated canola oil (low in linoleic acid) had significantly lower acceptability than its other frying counterparts (high linolenic acid<mid linolenic acid<palm olein<low linolenic acid<sunflower oil) having linoleic acid in the range of 13.8%-32.4%.

The popularity of foodstuffs covered with tempura-type frying battered products has increased worldwide (Patton D, 2005). In this type of food, a chemically leavened batter serves as the outer coating of the food piece; giving good visual and structural characteristics to the product (Loewe R, 1993). Popularity and simultaneous increase in demand of these products

amongst the consumers ensure good sensory acceptability of battered foods. Many existing studies on frying batters mainly analyze the characteristic of the basic ingredient, wheat flour for their sensory qualities (Cunningham FE and Tiede LM, 1981; Hsia HY, Smith DM and Steffe JF, 1992).

Another popular deep fried product consumed in all sections across the ethnic groups of India was also studied for their sensory qualities at intermittent intervals of frying using CSO and GNO. Potatoes coated with bengal gram flour (Bhajias) are popular snack food, were assessed for their sensory qualities at intermittent intervals. A non significant increase in appearance and color scores noticed in bhajias fried in CSO and GNO as the duration of frying increased from 0 h to 21 h. Study by Shih FF et al (2005) revealed, when okras were coated with varying levels of rice flour for deep frying, all the 3 studied formulations did not differ significantly for appearance attribute while the color scores improved significantly giving a desirable golden brown intensity. Baixauli R et al (2002) showed color of the fried battered squid rings was affected by both frying temperature and frying time. Change in color of fried products to golden brown color as the result of maillard reaction that depends on the content of reducing sugars and amino acids or proteins at the surface and temperature and time of frying (Nawar WW, 2000; Warner K, 2004).

Crispness is a highly valued and universally liked textural characteristic that indicates freshness and high quality. Probing into consumer attitudes to texture and its specific attributes, Szczesniak AS and Kahn EE (1971) concluded that crispness appears to be the most versatile single texture parameter. In the present study crispness scores of bhajias fried in polyunsaturated rich CSO had higher values as compared to monounsaturated rich GNO. However, F-test showed no significant change in crispness scores of bhajias. When different levels of additives used in *diamond cuts*- wheat flour based snack, deep fried in sunflower oil non significant change were observed in textural quality of the final product (Gowri BS et al,

2008). In an another study, where batter coated (wheat flour, baking powder, and three different gums; guar, xanthan and locust bean) frozen fish fillets were fried in hydrogenated palmolein margarine, no significant difference in appearance and texture was seen; indicating little contribution of the additives in the batter to textural qualities of the end product (Kilincceker O, Dogan IS and Kucukoner E, 2009).

In one study when breaded chicken nuggets were deep fried, cooked in convention oven or in microwave oven it was found that crispness in breaded chicken nuggets cooked in a deep-fat fryer was significantly crispier ($p<0.05$) than chicken nuggets cooked in either a convection oven or a microwave oven (Antonova I and Mallikarjunan P, 2004). Although in our study only one system of frying was used-open pan frying, studies have indicated varying effects on the textural quality of end product when different frying systems were used. This study indicates that crispier bhajias (the most desirable quality of the product) can be tried out by frying them using a deep fat fryer.

Various studies have shown that greasiness of fried foods is dependent on time and temperature of frying (Farkas BE et al, 1992; Gamble MH and Rice P, 1988; Pinthus EJ, Weinberg P and Saguy IS, 1993). Present work showed that greasiness of bhajias prepared in cottonseed oil was more than groundnut oil. However, there was no significant change observed in the greasiness scores up to 21 h of intermittent frying for both the oils. A study by Du-Ling et al (1998) observed that as the frying process progressed, an outer crust is formed on the product that made it more difficult for fat to penetrate into the product. Pokorny J and Reblova Z (1999) studied the transfer of oil to fried product and they concluded that pre-frying, battering and pre-heating of products may probably be good methods to inhibit absorption of oil during frying. No change in greasiness of the fried product was seen when coating of wheat flour and corn flour on chicken patties and resistant starch on frozen squid rings was done (Mah E and Brannan RG, 2009; Sanz T, Salvador A and Fiszman SM, 2008).

Extent of duration of frying did not alter the flavor, taste and odor of bhajias in both the oils. However, bhajias prepared in CSO showed better flavor, taste and odor scores as compared to GNO fried bhajias. Better scores of bhajias fried in CSO could be due to linoleic acid, as earlier reported studies said, linoleic acid is responsible for desirable deep-fat fried flavor (Warner K, Orr P and Glynn M, 1997). In addition, flavor of fried foods also depends on the type of oil and number of fryings (Prevot A et al, 1988).

In the present study, although the bhajias were fried 25 times in the same oil no significant changes were observed in the flavor of bhajias. The flavor of bhajias are depend on the taste, present taste results are comparable with the flavor scores where cottonseed oil fried bhajias had better scores than those fried in groundnut oil. Taste is the sum of the sensations perceived which is attributed to the inherent chemical compounds of food and to a greater extent by flavor and off-flavor imparted by the oil types used (Ikpeme CAE, Eneji CA and Essiet U, 2007). Like rest of the sensory parameters overall acceptability of cottonseed oil prepared bhajias was higher than those of bhajias fried in groundnut oil. Better overall acceptability scores of cottonseed oil fried bhajias may perhaps be the influence of other sensory attributes i.e. flavor, taste and odor.

In the present study, bhajias and french fries fried in GNO showed higher oil uptake than CSO. Similar results were obtained in a study conducted on legumes and cereal based deep-fried snacks fried in different vegetable oils. Highest oil uptake was observed by peanut oil (35.9%) and lowest by cottonseed oil (30.6%) (Annapure US, Sinhal RS and Kulkarni PR, 1998). Kita A, Lisinska G and Golubowska G (2007) revealed that fat absorption is greatly influenced by frying temperature. Frying at higher temperature (190^{0}C) in peanut oil decreased the oil uptake in potato crisps.

To conclude, frying of french fries alters the sensory qualities when fried intermittently up to 21 h whereas bhajias showed no significant change in sensory qualities when fried up to 21 h of intermittent frying. In view of overall acceptability, french fries fried in GNO were more acceptable than CSO prepared fries (up to 6 h of intermittent frying).

PHASE III

5.3: CHEMICAL CHANGES DUE TO THERMAL DEGRADATION OF INTERMITTENTLY DEEP FRIED COTTONSEED OIL (CSO) AND GROUNDNUT OIL (GNO) AS A RESULT OF FRENCH FRIES AND BHAJIAS FRYING

Deep-fat frying is one of the oldest and popular food preparations because it is fast, convenient, and such foods are generally liked for flavor and texture. Deep-fat frying is more a technology than science. Deep-fat frying can be defined as process of controlled dehydration and browning with hot oils as the heat transfer medium (Singh S and Tyagi VK, 2001). It involves both mass transfer and heat transfer.

During deep-fat frying, the oil is continuously or repeatedly used at elevated temperature in the presence of air. During frying, a variety of reactions cause a spectrum of physical and chemical changes. In the presence of oxygen from either the air or the product, food moisture, and high temperature, oil undergoes mainly three deleterious reactions: hydrolysis caused by water, oxidation and thermal alterations caused by oxygen, and heat, respectively (Nawar WW, 2000).

A significant proportion of edible oils are used worldwide for deep-fat frying for various foodstuffs. The decomposition products developed as a result of deep frying are however a cause of concern from health point of view. In view of this, III phase of the present study comprised of determining the thermal degradation of two popular consumed oils in Gujarat viz. a viz. cottonseed and groundnut oil fried at intermittent durations. Refined cottonseed and double filtered groundnut oil was heated up to 180^{0}C for frying french fries and bhajias at intermittent intervals for 25 h (actual frying 2.5 h). 75ml of fried cottonseed and groundnut oil was pipette out at the end of each day (0, 5, 10, 15, 20 and 25 h) and assessed for its chemical and physical parameters. Average temperature maintained in CSO and GNO

during frying french fries (CSO and GNO) and bhajias (CSO and GNO) is shown in Figure 5.3.1 and 5.3.2 respectively.

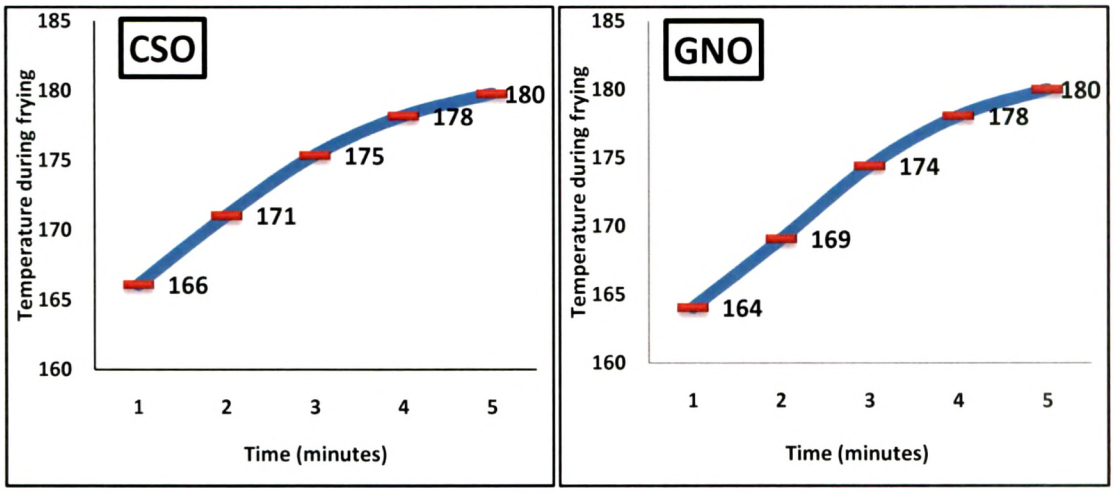


Figure 5.3.1: Rise in average temperature during frying of french fries in CSO and GNO

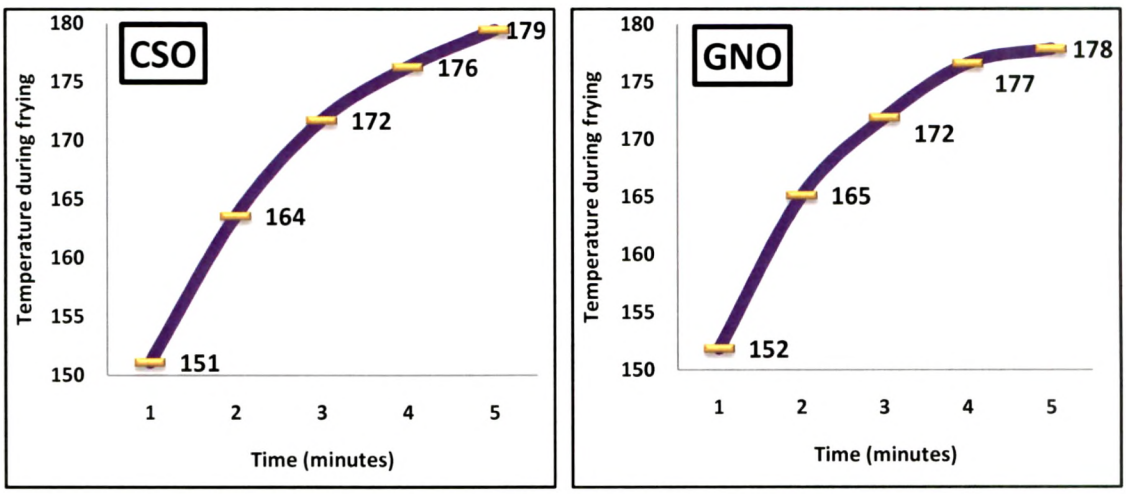


Figure 5.3.2: Rise in average temperature during frying of bhajias in CSO and GNO

The results of this phase are presented under the following heads:

5.3.1: Intermittent frying stability of CSO and GNO used for frying french fries in terms of its breakdown products

5.3.2: Intermittent frying stability of CSO and GNO used for frying bhajias in terms of its breakdown products

5.3.3: Correlation of french fries and bhajias sensory attributes with chemical parameters of french fries and bhajias fried CSO and GNO

5.3.1: Intermittent frying stability of CSO and GNO used for frying french fries in terms of its breakdown products

A. Chemical parameters

I. Peroxide value (PV)

As seen in Figure 5.3.1.1, at 0 h the primary oxidation (PV) of CSO was significantly higher ($p>0.001$) than GNO when compared to limits of <10meq O_2/kg (Ranganna S, 2003). Thereafter PV progressively increased in both the oils but GNO had significant higher ($p<0.01$) value at 10 h of intermittent frying. However, at 25 h of frying duration GNO showed lower peroxide values than CSO though the difference was not statistically significant. The percent increase in PV for CSO and GNO was 98.4% and 308.2% respectively. Student 't' test showed a significant ($p<0.05$) difference in CSO and GNO PV at 0 and 10 h of intermittent frying (Appendix 11.4a).

Regression equations have indicated positive correlation between the frying time and PV for both the oils (Figure 5.3.1.2).

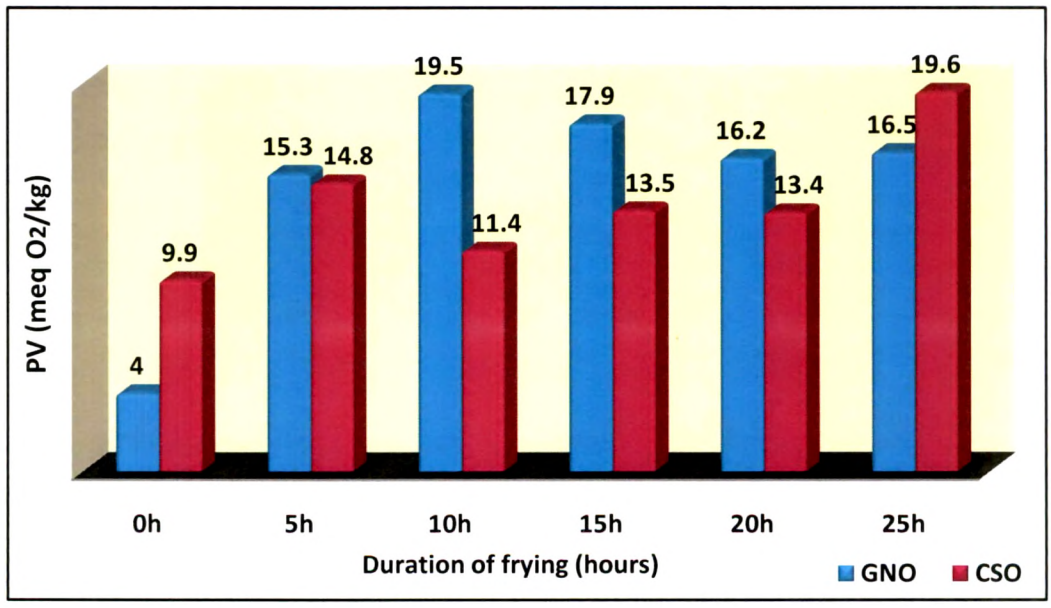


Figure 5.3.1.1: Peroxide value of CSO and GNO at intermittent frying intervals

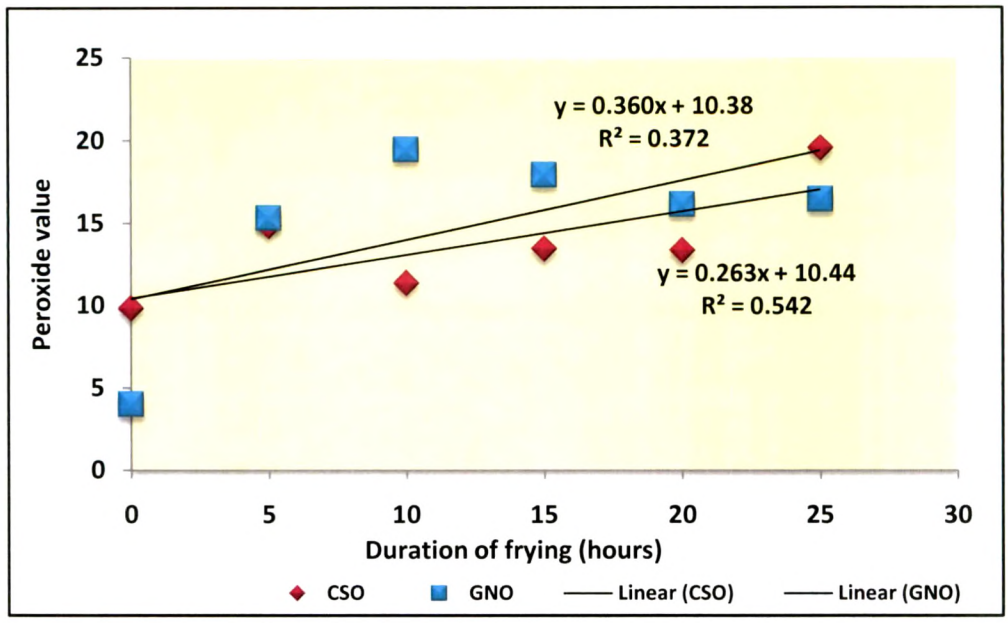


Figure 5.3.1.2: Relation between peroxide value and duration of frying

II. p-anisidine value (p-AV)

CSO at 0 h showed significantly higher ($p<0.001$) p-anisidine value than GNO (Figure 5.3.1.3). Generally the p-AV of good quality oil should be less than 2.0 (Bhattacharya AB et al, 2008). p-AV mainly accounts as degradation products of peroxides rose significantly ($p<0.001$) to 93.3 and 53.61 in CSO and GNO respectively at 5 h of frying duration, which continued to increase thereafter up to 25 h. p-AV of CSO remained significantly higher ($p<0.001$) than GNO during the entire period of frying (Appendix 11.4a). Peroxide and p-anisidine values also showed a strong correlation of r=0.78 (GNO) and r=0.66 (CSO).

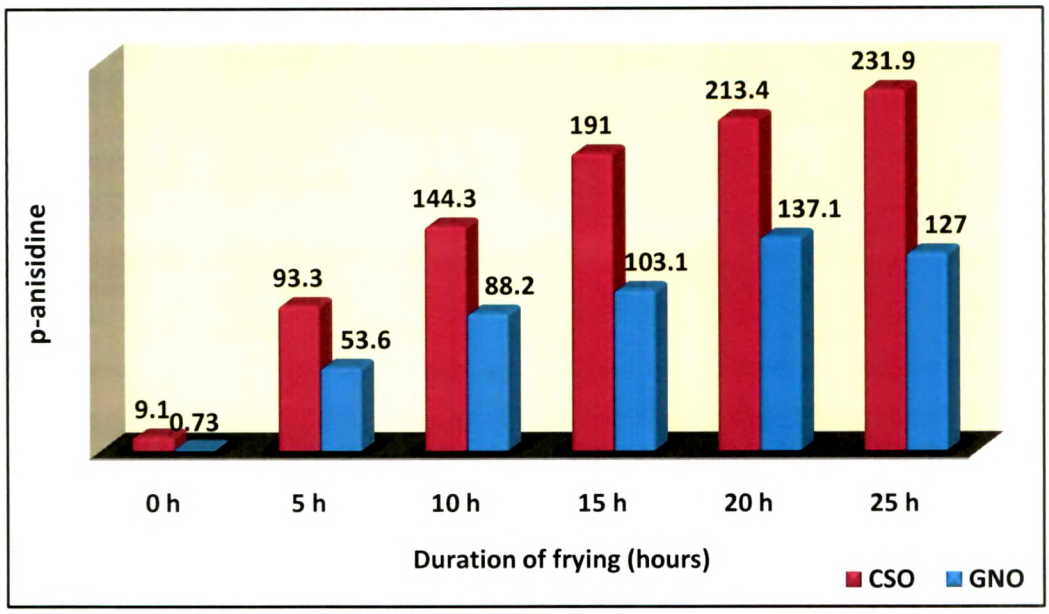


Figure 5.3.1.3: p-anisidine value of CSO and GNO at intermittent frying intervals

p-anisidine values strongly correlated with frying duration for both, GNO (r^2=0.89) and CSO (r^2=0.93) as shown in Figure 5.3.1.4.

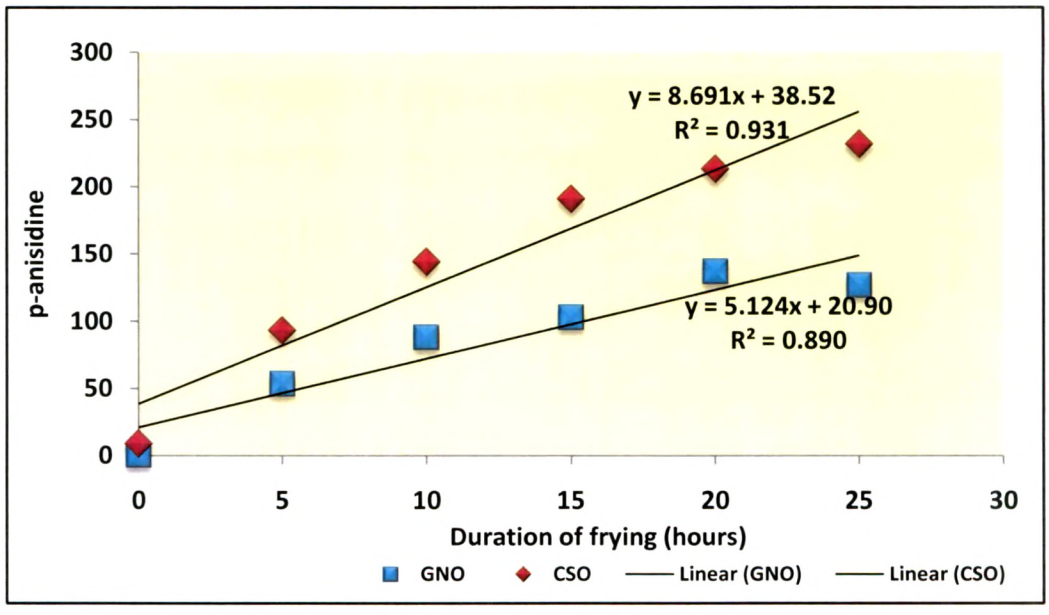


Figure 5.3.1.4: Relation between p-anisidine value and duration of frying

III. Totox value (TV)

The TOTOX (i.e. total oxidation products) value of both the oils used for french fries frying was significantly ($p<0.001$) increased (Table 5.3.1.1). ANOVA value of CSO showed higher oxidation products than GNO.

Table 5.3.1.1: Totox value of GNO and CSO at intermittent intervals of french fries frying

Duration of frying (hours)	Totox value	
	GNO	CSO
0 h	8.77±1.0^{a}	28.7±8.2^{a}
5 h	84.25±9.6^{b}	122.9±2^{b}
10 h	127.1±6.7^{c}	167.1±2^{c}
15 h	138.9±8.9^{c}	217.9±5^{d}
20 h	169.4±2.9^{d}	240.1±8.6^{e}
25 h	159.6±5.1^{e}	270.9±6.6^{f}
F-value	339.77***	859.17***

Note: ***-Significant at $p<0.001$; The superscripts with similar alphabets in each row indicate no significant difference between the values

IV. Iodine value (IV)

Iodine value, a measure of overall unsaturation and is widely used to characterize oils and fats. It is expressed in terms of the number of milligrams of iodine absorbed/g of the sample (AOAC, 1995). Vegetable oil products order (VOPO) has laid down the standard limit for GNO and CSO between 85 to 99 and 98 to 112 respectively (VOPO, 1998).

Iodine value, at 0 h of both the oils was found within the suggested limits. A statistically significant ($p<0.001$) decrease, CSO (3.2%) and GNO (3.6%) was observed at the end of 5 h of intermittent frying (Table 5.3.1.2). Iodine value of CSO crossed the lower limit (95.33) at 10 h of frying duration but GNO remained stable. However, at 25 h of intermittent frying GNO crossed the lower limit (81.36) set by VOPO. A total of 14.45% and 17.64% decrease was

observed in CSO and GNO respectively at the end of 25 h of intermittent frying period.

Table 5.3.1.2: Iodine value (mg I_2/g of oil) of GNO and CSO at intermittent intervals of french fries frying

Duration of frying (hours)	Iodine value	
	GNO	CSO
0 h	98.79±0.31[a]	102.38±0.36[a]
5 h	95.23±0.51[b]	99.1±0.8[b]
10 h	89.9±0.49[c]	95.33±0.61c
15 h	87.89±0.44[d]	91.36±0.65[d]
20 h	86.1±1.87[d]	87.3±0.78[e]
25 h	81.36±0.79[e]	87.58±2.38[e]
F-value	**194.52****	**116.77****

Note: **- significant at p<0.01; The superscripts with similar alphabets in each row indicate no significant difference between the values

Figure 5.3.1.5 shows a strong relation between IV and increased frying time in both the oils (CSO r^2=0.96, GNO r^2=0.97).

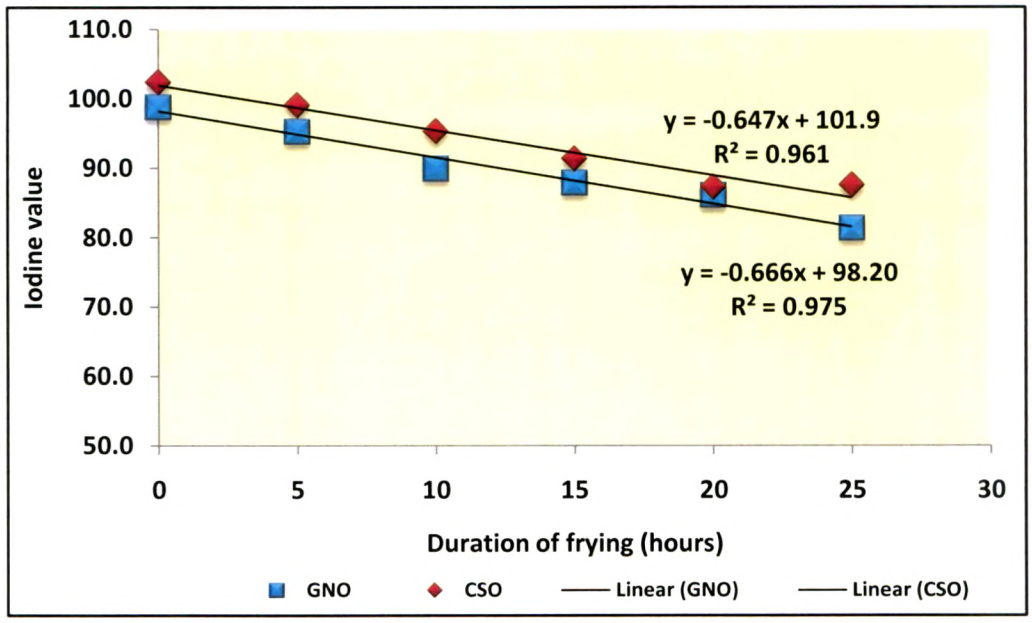


Figure 5.3.1.5: Relation between Iodine value and duration of frying

V. Acid value (AV)

Acid value, a hydrolytic parameter used to assess degradation of frying oils is shown in Table 5.3.1.3. The initial acid value of both the oils was within the set limits, suggested by VOPO i.e. for GNO acid value was <6 mg KOH/g and <0.5 mg KOH/g of sample for CSO (Vegetable oil products order, 1998).

The AV was found to be different in both the samples at initial levels because of different grades of oils i.e. refined (CSO) and filtered (GNO). At the end of 5 h of intermittent frying, AV increased by 20% in both the oils. Increase in hydrolytic changes of both the oils at the end of intermittent frying was statistically significant ($p<0.001$). AV of CSO at 20 h of frying interval was very close to the standard limit and reached to 0.80 mg KOH/g at 25 h of frying. However, the hydrolytic degradation in GNO was within limits of VOPO even after 25 h of intermittent frying. Increased frying time showed a strong relation with AV (Figure 5.3.1.6) of both the fried oils with $r^2=0.90$ for CSO and $r^2=0.91$ for GNO respectively.

Table 5.3.1.3: Changes in acid value (mg KOH/g) of GNO and CSO at intermittent intervals of french fries frying

Duration of frying (hours)	Acid value	
	GNO	CSO
0 h	0.60±0.02^{a}	0.10±0.01^{a}
5 h	0.72±0.08^{b}	0.12±0.05^{a}
10 h	0.83±0.06^{b}	0.20±0.03^{b}
15 h	1.04±0.18^{bc}	0.36±0.02^{c}
20 h	1.13±0.19^{bc}	0.49±0.03^{d}
25 h	1.62±0.36^{bc}	0.80±0.10^{e}
F-value	15.389**	111.00**

Note: **Significant at -p<0.01; The superscripts with similar alphabets in each row indicate no significant difference between the values

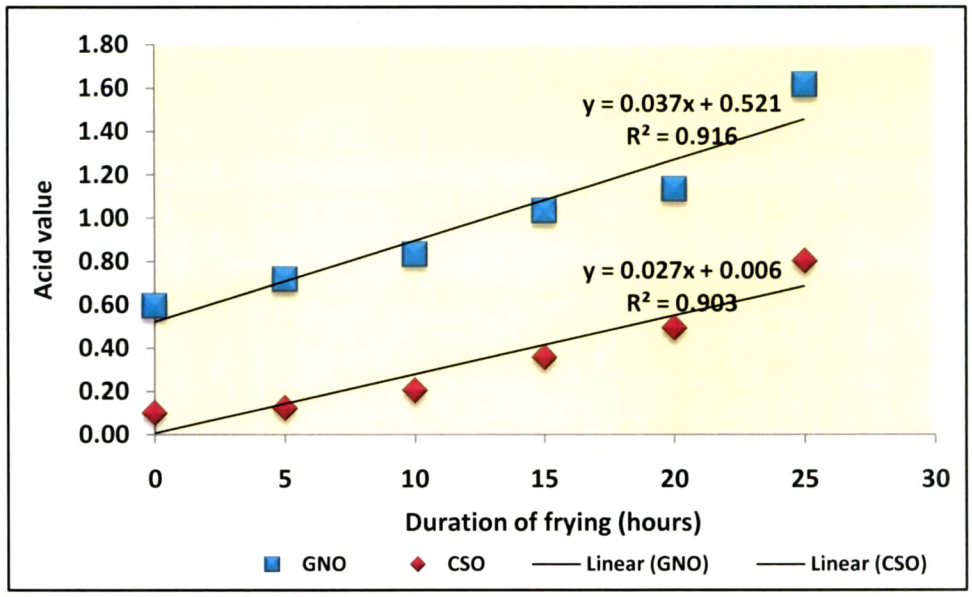


Figure 5.3.1.6: Relation between acid value and duration of frying

VI. Total polar components (TPC)

The content of total polar compounds determined by gravimetric separation of non-polar components using column chromatography is shown in Figure 5.3.1.7. At 0 h the TPC of CSO was significantly higher ($p<0.001$) than GNO. At 15 h of intermittent frying the TPC of CSO was 98.5% higher than GNO. At 25 h, the TPC show a total 83.8% and 89.4% increase in CSO and GNO respectively from the baseline values, which was still below the safe limits set by many European countries (Singh S and Tyagi VK, 2001). Plate 5.3.1.1 shows the thin layer chromatograph used to check the efficiency of column chromatography.

A strong correlation was observed between polar components and duration of frying ($r^2=0.99$ for CSO and $r^2=0.91$ for GNO) (Figure 5.3.1.8). CSO had significant higher ($p<0.001$) values than GNO at 0, 15 and 25 h of intermittent frying (Appendix 11.4a).

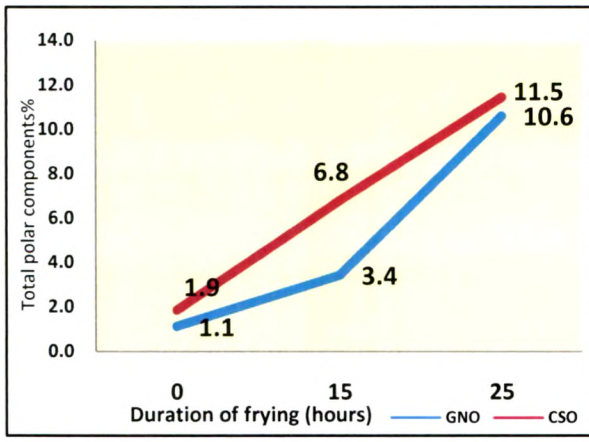


Figure 5.3.1.7: Total polar components (%) at intermittent frying intervals

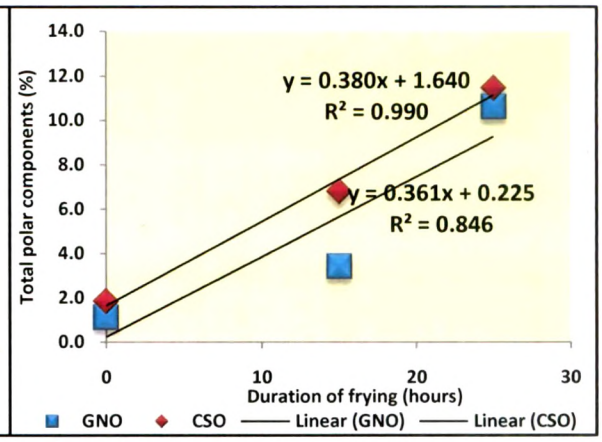


Figure 5.3.1.8: Relation between Total polar components and duration of frying

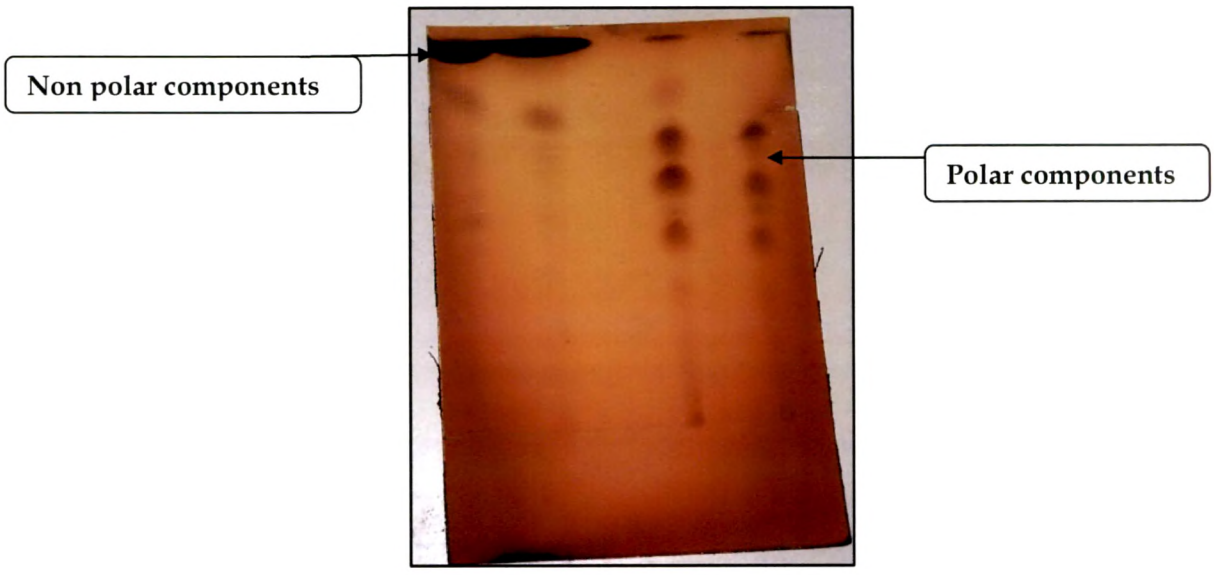


Plate 5.3.1.1: Thin layer chromatograph shows the polar and non polar components separated by column chromatography from french fried CSO

VII. Fatty acid profile

The saturated fatty acid content of CSO and GNO significantly increased with the increase in frying hours (Table 5.3.1.4). Palmitic acid increased up to 16.4% and 11.8% in CSO and GNO respectively at the end of 25 h intermittent frying. No significant change was observed in palmitoleic acid of both the fried oils. Increase in stearic acid was not significant in CSO, however stearic acid in GNO increased significantly ($p<0.01$). The major fatty acid of GNO, the oleic acid (n-9) increased by 4.4% and linoleic acid showed a decrease of 26% at the end of 25 h intermittent frying. However, no significant (student 't') increase was observed in oleic acid at 15 h and 25 h of frying duration of GNO. CSO rich in linoleic acid (n-6) decreased by 12.7% at 25 h of intermittent frying and oleic showed a significant increase ($p<0.01$) of 9.2%. Linolenic acid in GNO was totally missing with increased frying time. In the present study, significant decrease ($p<0.001$) and ($p<0.01$) was observed in 18:2/16:0 ratio by 33.8% and 25% in GNO and CSO respectively.

Fatty acid profile chromatograms of French fries fried GNO and CSO at 0 and 25 h are shown in Plate 5.3.1.2.

Table 5.3.1.4: Fatty acid profile (g/100 g fat) of cottonseed oil (CSO) and groundnut oil (GNO) at intermittent intervals

Fatty Acids		Frying Time (hours)			F-value
		0 h	15 h	25 h	
16:0 (Palmitic)	CSO	24.0±0.06^{a}	26.1±0.20^{b}	27.9±0.16^{c}	346.8***
	GNO	9.78±0.45^{ab}	10.5±0.09^{ab}	10.9±0.07^{abc}	9.5*
16:1 (Palmitoleic)	CSO	0.60±0.01	0.63±0.01	0.66±0.03	6.05^{NS}
	GNO	0.06±0.08	0.09±0.01	0.08±0	0.31^{NS}
18:0 (Stearic)	CSO	2.9±0.02	2.9±0.21	3.1±0.12	1.5^{NS}
	GNO	3.1±0.04^{a}	3.2±0.01^{b}	3.4±0^{c}	114.1**
18:1 (Oleic)	CSO	18.6±0.07^{a}	19.7±0.18^{b}	20.3±0.06^{c}	107.7**
	GNO	58.7±0.16^{a}	60.8±0.54^{b}	61.3±0.06^{b}	34.4**
18:2 (Linoleic)	CSO	50.9±0.18^{a}	47.1±0.30^{b}	44.4±0.15^{c}	435.8***
	GNO	21.9±0.31^{a}	18.8±0.62^{b}	16.2±0.59^{b}	58.0**
18:3 (Linolenic)	CSO	0.34±0.01^{a}	0.37±0^{b}	0.39±0.01^{b}	39.5**
	GNO	0.21±0.02	ND	ND	-
18:2/16:0	CSO	2.1±0.01^{a}	1.8±0^{b}	1.5±0.01^{c}	1739.4***
	GNO	2.2±0.08^{a}	1.7±0.08^{b}	1.4±0.06^{b}	54.4**

Note: *-Significant at p<0.05, **- Significant at p<0.01, ***- Significant at p<0.001, NS- not significant, ND-not detected; Mean ± SD followed by the same superscript in each row are not significantly different

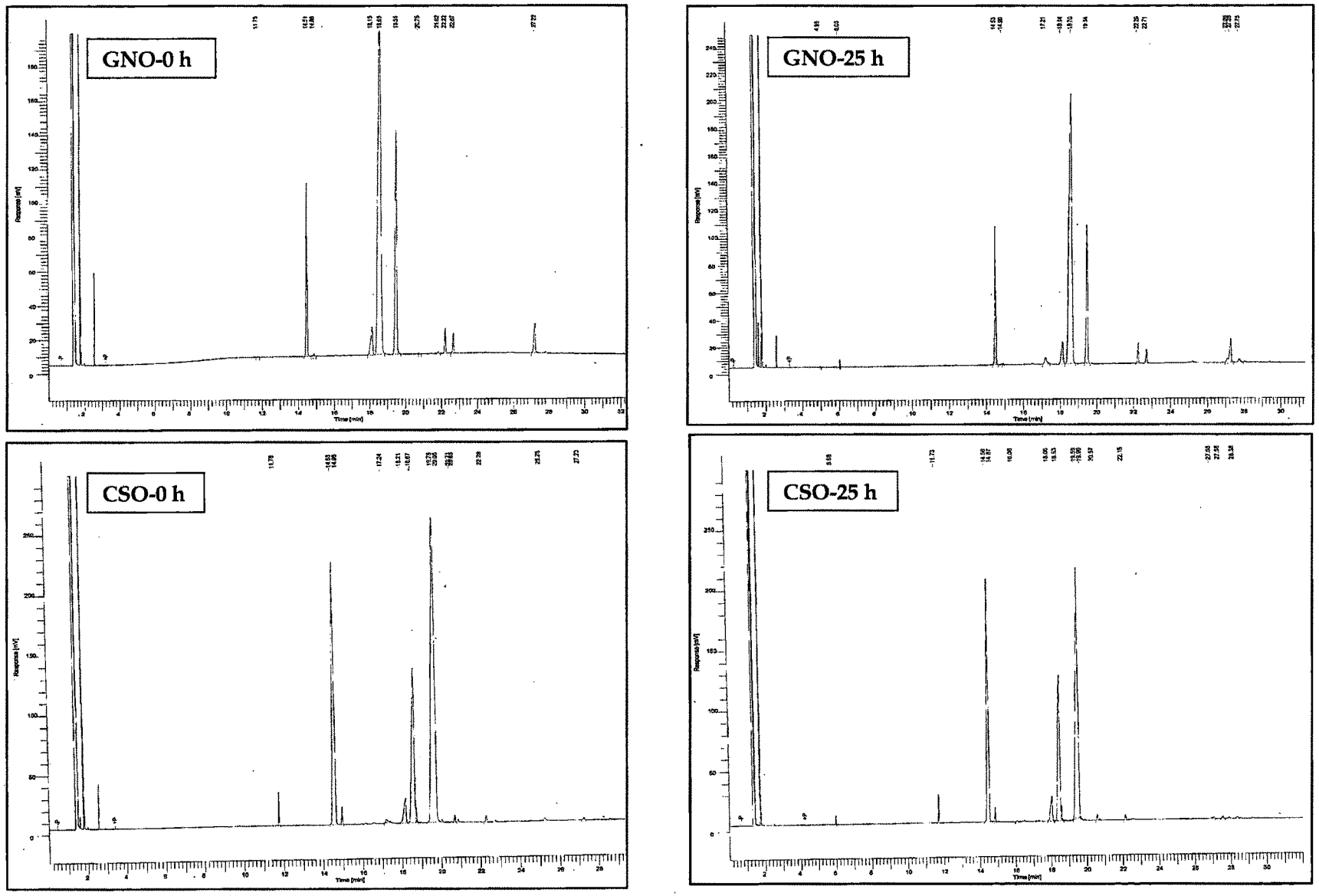


Plate 5.3.1.2: French fries fried GNO and CSO fatty acid profile chromatograms obtained at 0 and 25 h of intermittent frying

B. Physical parameters

I. Refractive index

The refractive index of fried oil is reported in Figure 5.3.1.9. The refractive index of GNO and CSO at 0 h was 1.4524 and 1.46405 respectively. Recommended refractive index in GNO is 1.4620-1.4640 and in CSO is 1.4630-1.4660 (VOPO, 1998). The refractive index of both the oils increased significantly ($p<0.001$) at the end of 25 h of frying duration. Both oils crossed the upper recommended limit at 25 h duration. Increased frying time showed a strong relation with refractive index (Figure 5.3.1.10) of both the fried oils with $r^2=0.99$ for CSO and GNO.

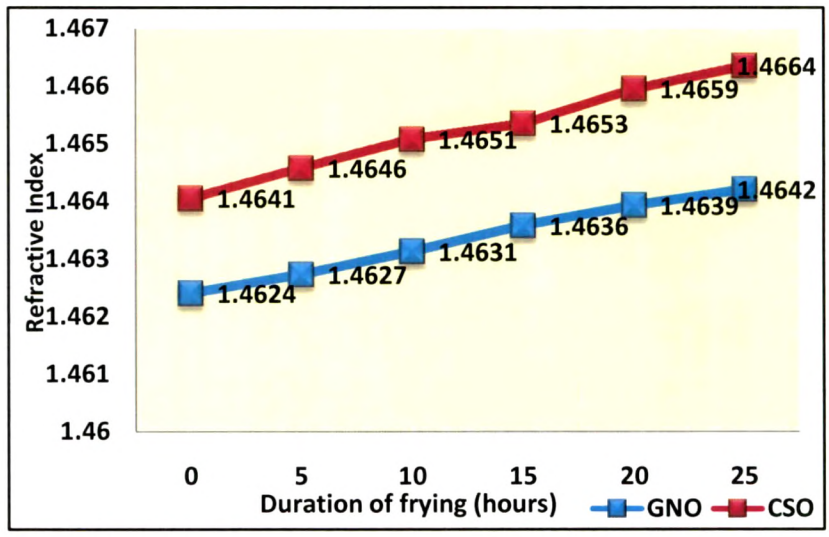


Figure 5.3.1.9: Refractive index of GNO and CSO at intermittent frying intervals

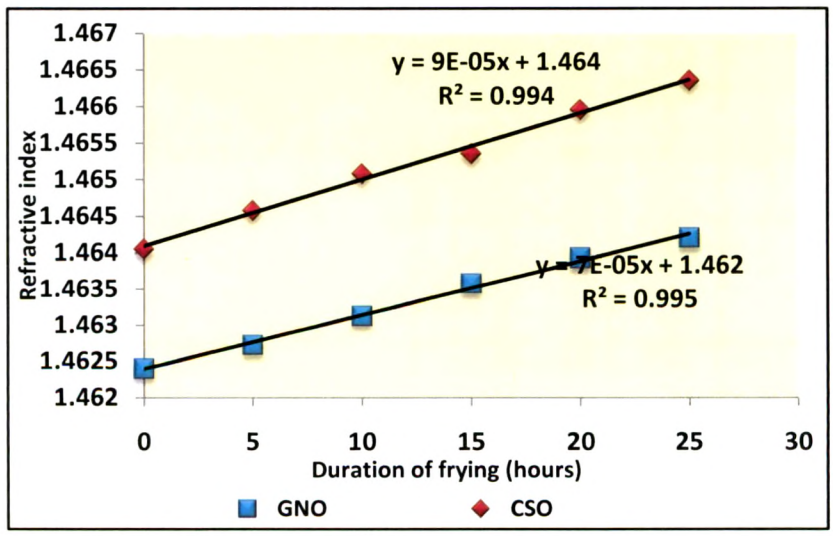


Figure 5.3.1.10: Relation between refractive index and duration of frying

II. Color

Change in color of fried oil is shown in Table 5.3.1.5. ANOVA analysis indicated significant increase ($p<0.001$) in color of both the oils during 25 h of intermittent frying. Student 't' showed no significant difference in color of both the oils up to 5 h of intermittent frying. After that a significant ($p<0.05$) increase in both yellow (Y) and red (R) color of GNO and CSO was noticed. Plate 5.3.1.4 shows the color of GNO before frying and 5.3.1.5 shows the change in color of french fries fried GNO.

Table 5.3.1.5: Change in color of GNO and CSO at intermittent intervals of french fries frying

Duration of frying (hours)	GNO		CSO	
	Y	R	Y	R
0 h	2.75 ± 0.65^{a}	5.5 ± 0.48^{a}	2 ± 0^{a}	6.5 ± 0.48^{a}
5 h	2 ± 0.29^{a}	7 ± 0.28^{a}	2.75 ± 0.42^{b}	5.5 ± 0.48^{a}
10 h	2.08 ± 0.30^{a}	10 ± 0^{b}	3.75 ± 0.41^{c}	11 ± 0.65^{b}
15 h	2.38 ± 0.57^{abc}	11 ± 0.5^{b}	4.2 ± 0.18^{cd}	11.5 ± 0.25^{bc}
20 h	3.53 ± 0.52^{abc}	10.5 ± 0.48^{b}	4.35 ± 0.25^{d}	14 ± 0.41^{bd}
25 h	3.73 ± 0.50^{abc}	13 ± 0.29^{bc}	4.83 ± 0.17^{e}	15 ± 0.29^{bd}
F-value	**8.57*** **	**13.03*** **	**58.06*** **	**18.87*** **

Note: *-significant at $p<0.05$, **- significant at $p<0.01$, ***- significant at $p<0.001$; Mean ± SD followed by the same superscript in each row are not significantly different

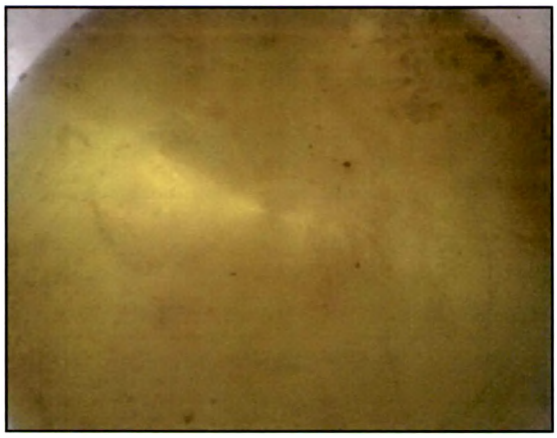


Plate 5.3.1.4: GNO color before 25 h of intermittent french fries frying

Plate 5.3.1.5: GNO color after 25 h of intermittent french fries frying

5.3.2: Intermittent frying stability of CSO and GNO used for frying bhajias in terms of its breakdown products

A. Chemical parameters

I. Peroxide value (PV)

Figure 5.3.2.1 shows the PV of GNO and CSO at different intervals of intermittent frying. Primary oxidation in cottonseed oil showed significant higher ($p<0.001$) values when compared with suggested limit i.e. <10meq O_2/kg than groundnut oil at 0 h (Ranganna S, 2003).

Upon frying the bhajias in CSO and GNO a significant ($p<0.001$) increase in PV was seen in both the oils at the end of 25 h of intermittent frying. PV of CSO decreased by 25% at the end of frying duration. GNO showed a progressive increase by 13% in PV up to 25 h of intermittent frying. No significant difference in PV value of both the oils was obtained at 10 h of intermittent frying (Appendix 11.4b).

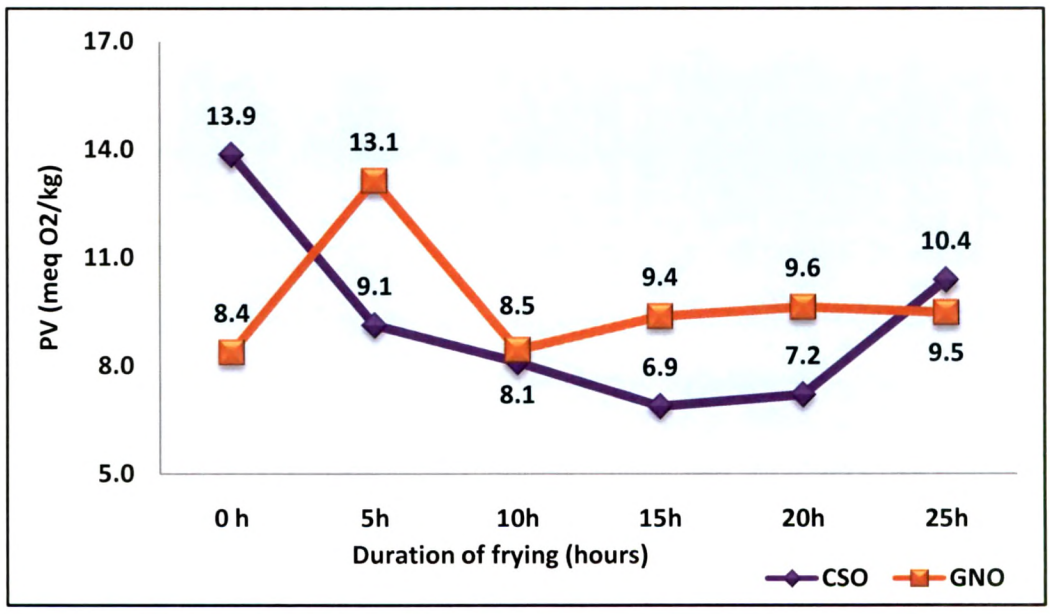


Figure 5.3.2.1: Peroxide value of GNO and CSO at intermittent frying intervals

Little correlation was observed between PV and duration of frying for both the oils (Figure 5.3.2.2).

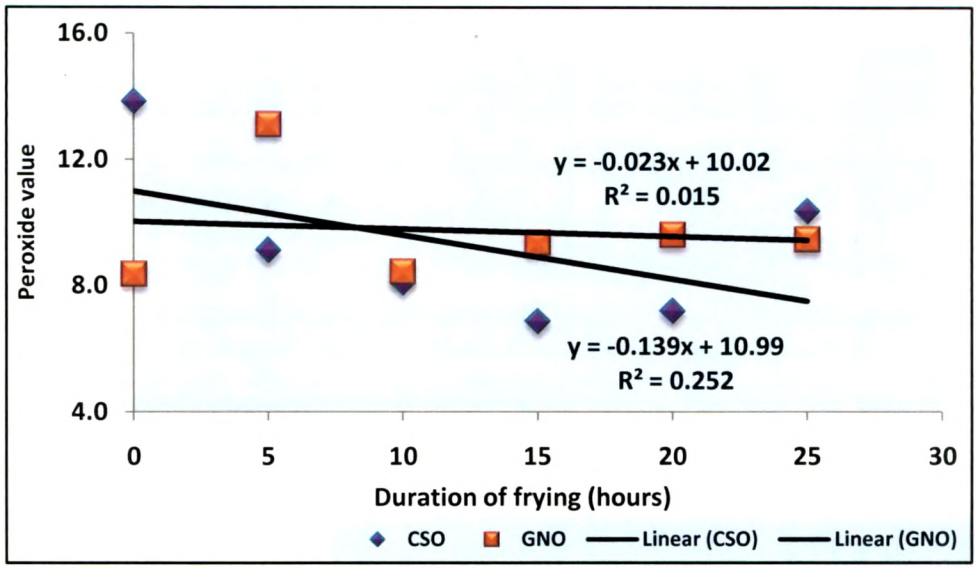


Figure 5.3.2.2: Relation between peroxide value and duration of frying

II. p-anisidine value (p-AV)

The secondary decomposition products assessed by p-AV are shown in Figure 5.3.2.3 and presented in Appendix (11.4b). At 0 h the p-AV of GNO and CSO was 0.58 and 8.71 respectively. However, CSO p-AV at 0 h was beyond the prescribed limit of 2 (Bhattacharya AB et al, 2008).

p-AV of CSO showed significant ($p<0.001$) increase from 62.09 to 85.47 at 5 and 10 h of intermittent frying of bhajias. GNO p-AV increased significantly ($p<0.001$) from 61.53 to 82.64 at 5 h and 10 h of bhajias frying. Increase in p-AV was continued to 25 h of intermittent frying duration of bhajias. Peroxide and p-anisidine values of CSO showed a negative correlation of r=-0.72 and GNO showed no relation r=0.08.

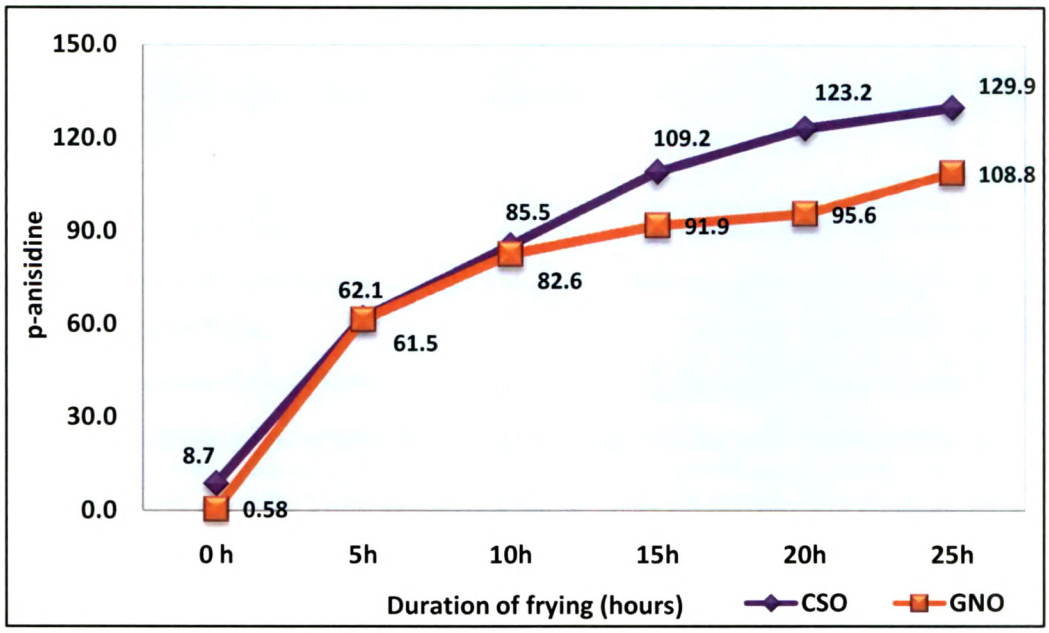


Figure 5.3.2.3: p-anisidine value of GNO and CSO at different frying intervals

As shown in Figure 5.3.2.4, p-anisidine value of CSO and GNO showed a strong linear relation with frying duration of bhajias.

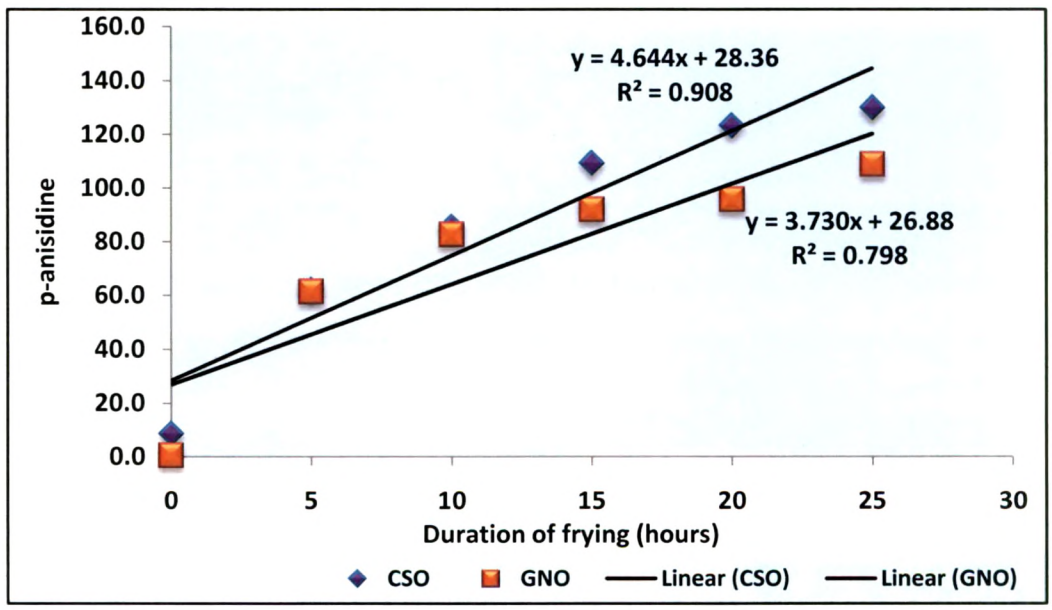


Figure 5.3.2.4: Relation between p-anisidine value and duration of frying

III. Totox value (TV)

The total oxidation products (TV) were significantly ($p<0.001$) formed in both the oils as the duration of bhajias frying increased (Table 5.3.2.1).

Table 5.3.2.1: Totox value of GNO and CSO at intermittent intervals of bhajias frying

Duration of frying (hours)	Totox value	
	GNO	CSO
0 h	17.3±0.4[a]	36.4±0.9[a]
5 h	87.8±3.6[b]	80.3±1.2[b]
10 h	99.5±3[c]	101.7±3.5[c]
15 h	110.6±0.8[d]	122.9±2.3[d]
20 h	114.8±1.8[e]	137.6±3.4[e]
25 h	127.7±2[f]	150.6±4.3[f]
F-value	1199.02***	824.5***

Note: ***-significant at $p<0.001$; The superscripts with similar alphabets in each row indicate no significant difference between the values

IV. Iodine value (IV)

The standard limit for IV of GNO and CSO is between 85 to 99 and 98 to 112 respectively (VOPO, 1998). The IV of CSO was significantly ($p<0.05$) altered after 25 h of intermittent frying, indicating decrease in unsaturated fatty acids shown in Table 5.3.2.2. However, bhajias fried in GNO showed no significant change at 25 h of intermittent frying.

Table 5.3.2.2: Iodine value (mg I_2/g of oil) of GNO and CSO at intermittent intervals of bhajias frying

Duration of frying (hours)	Iodine value	
	GNO	CSO
0 h	82.96±0.51	98.76±0.16[a]
5 h	85.75±4.65	101.34±4.19[a]
10 h	87.32±0.74	100.89±4.86[a]
15 h	87.7±1.06	99.21±3.10[a]
20 h	85.85±4.95	104.99±0.66[ab]
25 h	83.03±5.03	104.3±1.57[ab]
F-value	1.37[NS]	2.96*

Note: *-significant at $p<0.05$; NS- not significant; The superscripts with similar alphabets in each row indicate no significant difference between the values

IV of GNO showed no relation with frying duration of Bhajias. However, regression equation showed a good relation (r^2=0.58) between IV of CSO and frying duration (Figure 5.3.2.5).

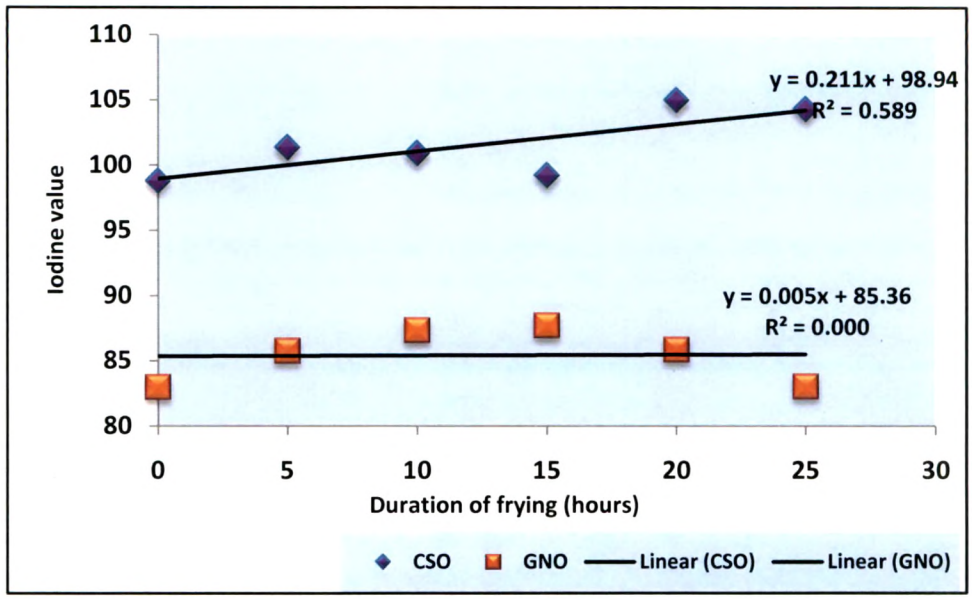


Figure 5.3.2.5: Relation between iodine value and duration of frying

V. Acid value (AV)

AV is popularly used for assessing the degradation of oils. Vegetable oil products order, 1998 suggested, AV for GNO and CSO was <6 mg KOH/g and 0.5 mg KOH/g of sample respectively. Acid value of GNO oil at 0 h was significantly ($p<0.001$) high because of different grades viz. filtered (GNO) and refined (CSO). As seen in Table 5.3.2.3, the AV continued to increase in both CSO as well as in GNO significantly ($p<0.001$) up to 25 h of frying. However, these values of both the oils were well in the acceptable limits.

Table 5.3.2.3: Acid value (mg KOH/g of sample) of GNO and CSO at intermittent intervals of bhajias frying

Duration of frying (hours)	Acid value	
	GNO	CSO
0 h	0.78±0.07[a]	0.12±0.02[a]
5 h	0.85±0.04[a]	0.15±0.01[b]
10 h	0.97±0.01[b]	0.18±0.01[c]
15 h	1.04±0.02[c]	0.26±0.02[d]
20 h	1.22±0.5[d]	0.35±0.01[e]
25 h	1.29±0.06[d]	0.47±0.03[f]
F-value	74.87***	207.68***

Note: ***-significant at p<0.001; The superscripts with dissimilar alphabets in each row indicate significant difference between the values

Regression equation showed a strong positive relation of AV with intermittent frying (25 h) duration of GNO and CSO (Figure 5.3.2.6).

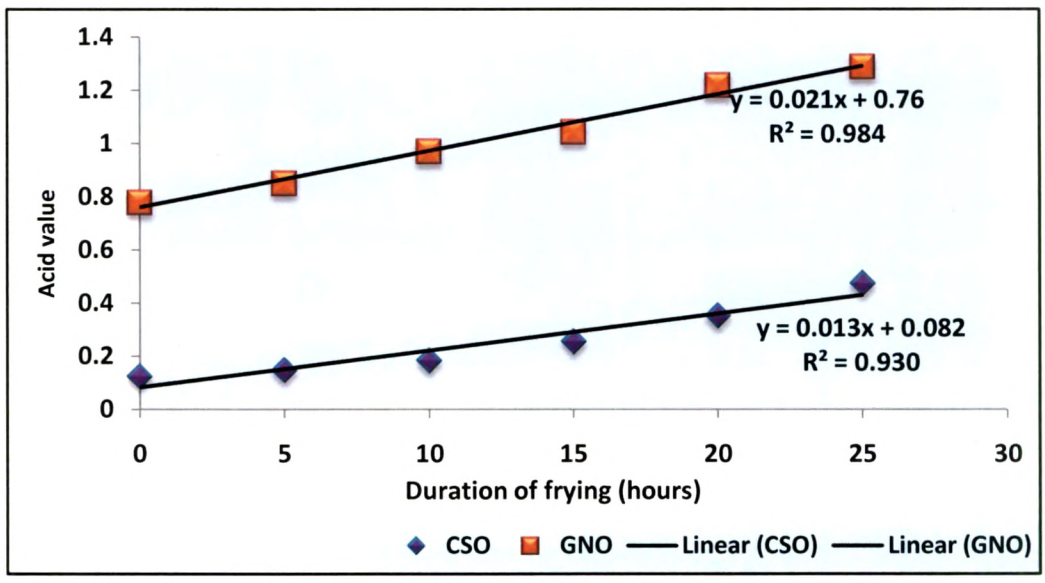


Figure 5.3.2.6: Relation between acid value and duration of frying

VI. Total polar components (TPC)

The results shown in Figure 5.3.2.6 showed that the contents of TPC increased almost linearly with the frying time. The initial TPC of GNO and CSO was 3.12 and 4, respectively, which was significantly ($p<0.001$) increased to 7.58 in GNO and 14.38 in CSO, at 25 h of intermittent frying.

The TPC of both the oils did not cross the limit of 25% as stated by European countries (Xu Xin-Qing, 1999). Student 't' test showed significant ($p<0.001$) difference amongst the TPC values of GNO and CSO (Appendix 11.4b).

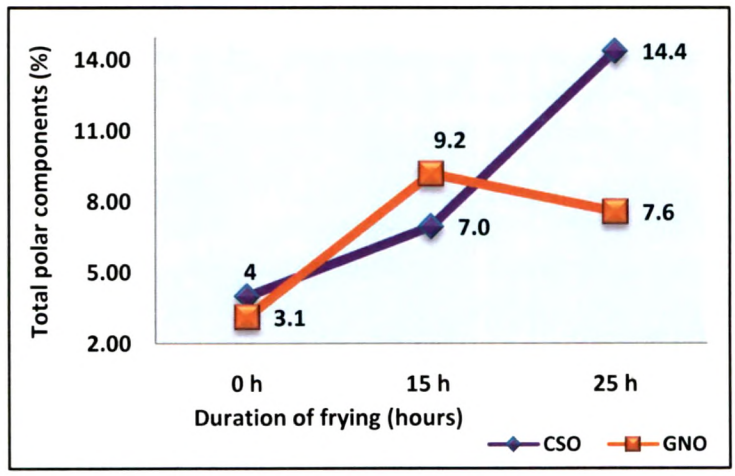


Figure 5.3.2.6: Total polar components (TPC) (%) of GNO and CSO at intermittent frying intervals

Figure 5.3.2.7 shows a strong positive correlation between TPC of CSO and GNO with duration of frying.

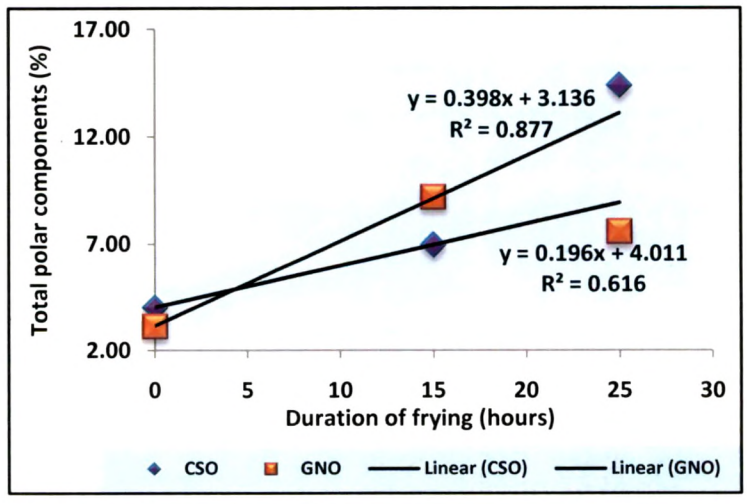


Figure 5.3.2.7: Relation between total polar components and duration of frying

VII. Fatty acid profile

Fatty acid profile of fried CSO and GNO are shown in Table 5.3.2.4. The saturated fatty acid content of GNO increased significantly ($p<0.05$) with the increase in frying hours. Palmitic acid was increased up to 6.21% and 6.8% in CSO and GNO respectively. 4.26% increase in stearic acid was observed in GNO at 25 h of intermittent frying. However, stearic acid in CSO did not significantly change. GNO rich in oleic acid (18:1) showed a significant ($p<0.001$) reduction of 1% at the end of frying duration. However, in CSO it showed a significant increase of 3.58%. Significant ($p<0.05$) decrease in polyunsaturated fatty acid (linoleic acid) of CSO was observed with increase in frying duration. The linolenic fatty acid of CSO was not significantly changed while the linolenic fatty acid of GNO was not detected at 15 and 25 h of intermittent frying. The linoleic acid to palmitic acid ratio (18:2/16:0) decreased significantly ($p<0.01$) in CSO whereas GNO 18:2/16:0 ratio showed no significant reduction during 25 h intermittent frying.

Fatty acid profile chromatograms of bhajias fried GNO and CSO at 0 and 25 h are shown in Plate 5.3.2.1.

Table 5.3.2.4: Fatty acid profile (g/100 g fat) of cottonseed oil (CSO) and groundnut oil (GNO) at intermittent intervals of bhajias frying

Fatty Acids		Frying Time (hours)			F-value
		0 h	15 h	25 h	
16:0 (Palmitic)	CSO	23.81±0.45	24.99±0.05	25.29±0.56	7.02^{NS}
	GNO	9.64±0.04^{a}	10.34±0.25^{b}	10.3±0.14^{b}	10.71*
16:1 (Palmitoleic)	CSO	0.59±0	0.62±0.02	0.6±0.01	1.46^{NS}
	GNO	0.08±0.01	0.07±0.02	0.08±0.0	0.7^{NS}
18:0 (Stearic)	CSO	2.58±0.11	3.03±0.01	2.98±0.04	4.02^{NS}
	GNO	3.05±0.01^{a}	3.2±0.03^{bc}	3.18±0.01^{bc}	33.17**
18:1 (Oleic)	CSO	18.7±0.10^{a}	19.3±0.27^{a}	19.37±0.02^{b}	9.78*
	GNO	59.12±0.53^{a}	59.96±0.06^{a}	58.5±0.28^{ab}	8.85*
18:2 (Linoleic)	CSO	50.76±0.07^{a}	48.81±0.07^{b}	49.5±0.65^{b}	13.54*
	GNO	22.79±0.70	20.31±1.07	19.85±2.02	2.63^{NS}
18:3 (Linolenic)	CSO	0.33±0	0.36±0.02	0.36±0.04	0.68^{NS}
	GNO	0.21±0.02	-	-	-
18:2/16:0	CSO	2.13±0.04^{a}	1.95±0.0^{b}	1.96±0.02^{b}	36.27**
	GNO	2.36±0.08	1.97±0.15	1.93±0.22	4.40^{NS}

Note: *-Significant at p<0.05, **- Significant at p<0.01, ***- Significant at p<0.001, NS- not significant, ND-not detected; Mean ± SD followed by the same superscript in each row are not significantly different

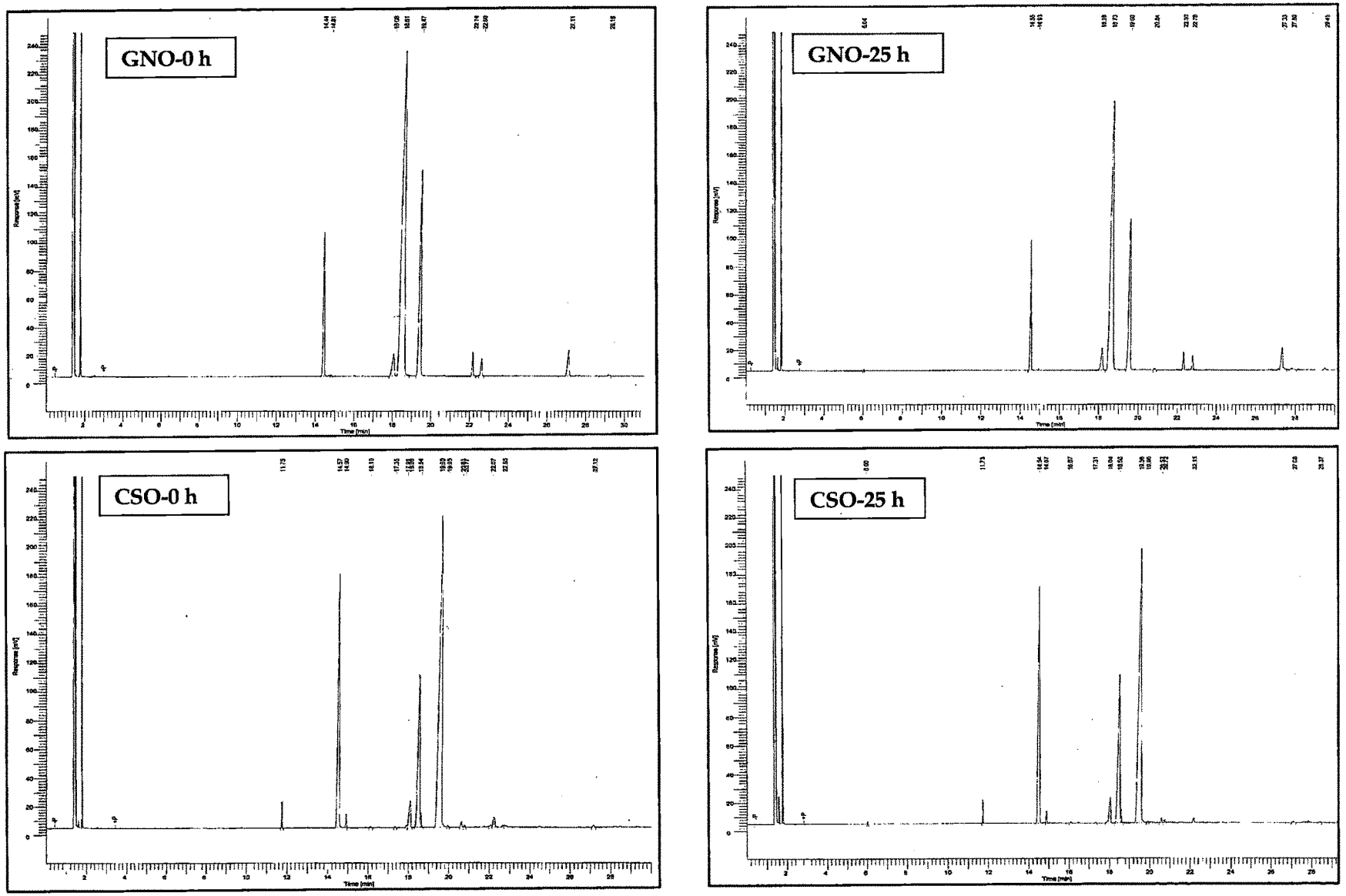


Plate 5.3.2.1: Bhajias fried GNO and CSO fatty acid profile chromatograms obtained at 0 and 25 h of intermittent frying

B. Physical parameters

I. Refractive Index (RI)

The RI and its relation with frying duration are presented in Figure 5.3.2.8 and 5.3.2.9. The refractive index of both the oils increased significantly ($p<0.001$) at the end of 25 h bhajias frying. However, both oils were within the recommended limit at 25 h of intermittent frying duration (GNO-1.4620-1.4640 and CSO-1.4630-1.4660). A strong positive relation of CSO and GNO with the duration of frying was observed.

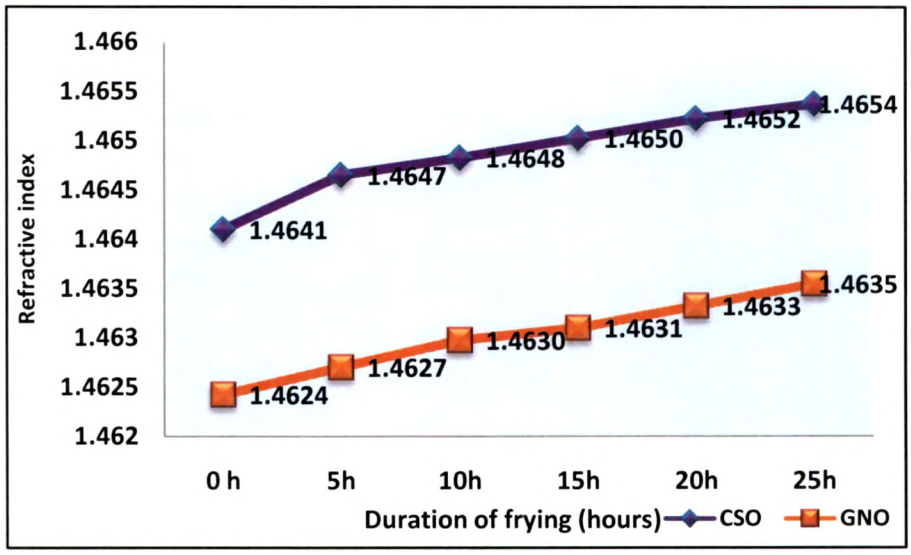


Figure 5.3.2.8: Refractive index of GNO and CSO at intermittent frying intervals

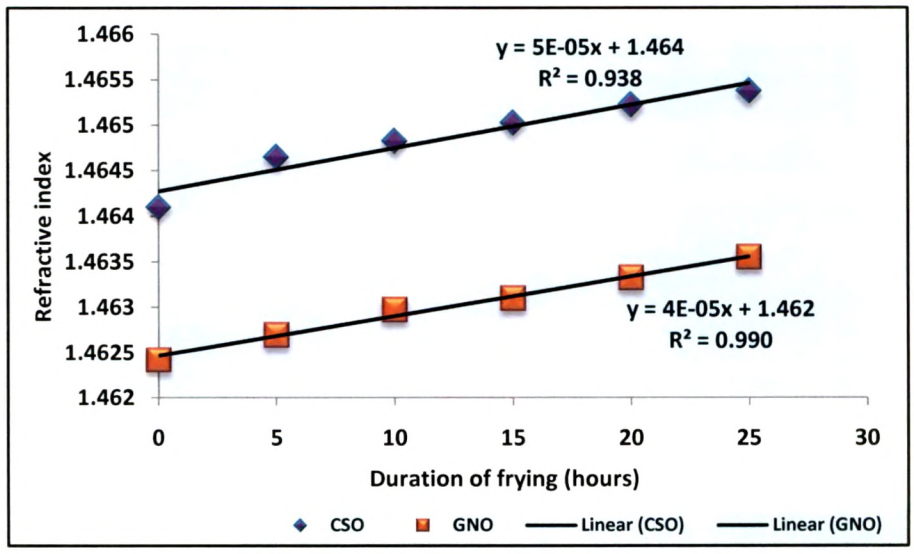


Figure 5.3.2.9: Relation between refractive index and duration of frying

II. Color

Change in color of fried oil is shown in Table 5.3.2.5. ANOVA analysis showed significant ($p<0.001$) increase in color of both the oils at the end of 25 h of intermittent frying. Significant increase ($p<0.05$) was observed in both yellow (Y) and red (R) color of bhajias fried CSO and GNO at 5 h of intermittent frying. Increase in color of both the oils was noticed up to 25 h of intermittent frying.

Change in color of CSO and GNO used for bhajias frying is shown in Plate 5.3.2.2 and 5.3.2.3.

Table 5.3.2.5: Change in color of GNO and CSO at intermittent intervals of bhajias frying

Duration of frying (hours)	GNO		CSO	
	Y	R	Y	R
0 h	3.4±0.08^{a}	1.88±0.25^{a}	2.18±0.24^{a}	1.63±0.25^{a}
5 h	4.03±0.40^{b}	4.53±1.68^{b}	3.91±0.12^{b}	2.50±1.0^{ab}
10 h	4.53±0.13^{c}	5.58±0.05^{b}	6.03±0.51^{c}	3.25±0.29^{b}
15 h	5.30±0.24^{d}	5.55±0.1^{b}	7.03±0.64^{cd}	5.00±0.0^{c}
20 h	6.98±0.35^{e}	5..83±0.10^{bc}	7.55±0.70^{d}	6.38±1.44^{c}
25 h	7.85±0.37^{f}	7.3±0.22^{d}	9.13±0.19^{e}	14.25±2.87^{d}
F-value	**144.06*** **	**25.73*** **	**120.95*** **	**44.67*** **

Note: *-significant at $p<0.05$, **- significant at $p<0.01$, ***- significant at $p<0.001$; Mean ± SD followed by the same superscript in each row are not significantly different

Before After

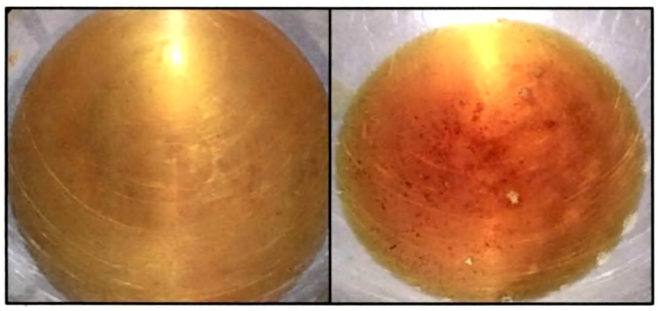


Plate 5.3.2.2: CSO color before and after 25 h of intermittent bhajias frying

Before After

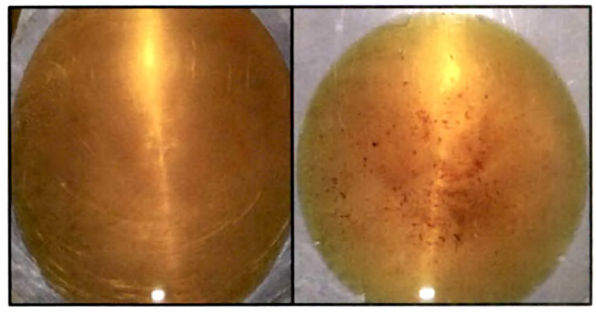


Plate 5.3.2.3: GNO color before and after 25 h of intermittent bhajias frying

5.3.3: Correlation of french fries and bhajias sensory attributes with chemical parameters of french fries and bhajias fried CSO and GNO

Products fried in oil for longer duration showed changes in their sensory and chemical quality of oil. The correlation coefficient of sensory attributes with chemical parameters is shown in Table 5.3.3.1.

A strong negative correlation in overall acceptability of french fries fried in GNO with different chemical parameters viz. peroxide value (r-0.80), p-anisidine (r-0.95) and acid value (r-0.89) was seen. However, iodine value showed a strong positive correlation (r 0.97) with overall acceptability (OA) of french fries fried in GNO. Whereas a negative correlation was seen in OA of CSO fried fries with peroxide (r-0.23), p-anisidine (r-0.29) and acid value (r-0.63). Overall acceptability of french fries in GNO was better correlated with chemical parameters than the OA of CSO. When odor, flavor and taste of french fries were correlated with the chemical parameters of CSO and GNO it was found that peroxide value, p-anisidine and acid value were have strong negative relation. Conversely, the iodine value of CSO and GNO was positively related with the odor and taste of french fries prepared in these oils. Greasiness scores of french fries prepared in CSO showed a strong negative correlation with p-anisidine and acid value (r-0.72 and r-0.89). GNO fried french fries greasiness scores also showed a strong negative correlation with the chemical parameters shown in table 5.3.3.1. However, iodine value of CSO and GNO revealed a strong positive correlation (r 0.81 and 0.94) with greasiness scores. Crispness of french fries showed a similar negative correlation with peroxide, p-anisidine and acid value of both the oils and iodine value showed positive relation with crispness scores of french fries.

Table 5.3.3.1: Correlation coefficient of sensory attributes with chemical parameters of french fries fried in CSO and GNO

Sensory attribute-chemical analysis	Type of oil	
	CSO	GNO
Overall acceptability	*Correlation coefficient (r)	
Overall acceptability- peroxide value	-0.23	-0.80
Overall acceptability-p-anisidine	-0.29	-0.95
Overall acceptability-acid value	-0.63	-0.89
Overall acceptability-iodine value	0.48	0.97
Odor		
Odor- peroxide value	-0.24	-0.52
Odor- p-anisidine	-0.69	-0.92
Odor- acid value	-0.94	-0.97
Odor- iodine value	0.84	0.91
Flavor		
Flavor- peroxide value	-0.43	-0.87
Flavor- p-anisidine	-0.53	-0.94
Flavor- acid value	-0.75	-0.84
Flavor- iodine value	0.64	-0.93
Taste		
Taste- peroxide value	-0.12	-0.87
Taste- p-anisidine	-0.28	-0.86
Taste- acid value	-0.6	-0.70
Taste- iodine value	0.44	0.83
Greasiness		
Greasiness - peroxide value	-0.36	-0.59
Greasiness - p-anisidine	-0.72	-0.93
Greasiness - acid value	-0.89	-0.94
Greasiness - iodine value	0.81	0.94
Crispness		
Crispness - peroxide value	-0.16	-0.56
Crispness - p-anisidine	-0.45	-0.79
Crispness - acid value	-0.74	-0.70
Crispness - iodine value	0.60	0.78

Note-*-significant at $p<0.05$

The correlation coefficient of sensory attributes with chemical parameters is shown in Table 5.3.3.2.

Correlation of bhajias overall acceptability fried in GNO with different chemical parameters was r=0.57 (peroxide value), r=0.31 (p-anisidine) and r-0.43 (acid value). Iodine value showed negative correlation (r -0.06) with overall acceptability of bhajias fried in GNO and CSO. Bhajias fried in CSO was better correlated with chemical parameters than the overall acceptability of GNO. When scores of bhajias for odor, flavor and taste were correlated with the chemical parameters of CSO it was found that peroxide value was not well correlated, p-anisidine showed a strong negative relation with taste of CSO fried bhajias. Acid value of CSO showed a strong negative relation with flavor (r-0.78) and odor (r-0.76) scores of bhajias. Conversely, the correlation values of GNO with flavor and taste was not related.

When greasiness scores of bhajias was correlated with p-anisidine and acid value both CSO and GNO showed a strong negative relation. Crispness of GNO fried bhajias was positively correlated with p-anisidine, and acid value. However, crispness scores of CSO bhajias were positively associated with acid and iodine value except peroxide value.

Table 5.3.3.2: Correlation coefficient of sensory attributes with chemical parameters of bhajias fried in CSO and GNO

Sensory attribute-chemical analysis	Type of oil	
	CSO	GNO
Overall acceptability	*Correlation coefficient (r)	
Overall acceptability- peroxide value	0.35	0.57
Overall acceptability-p-anisidine	-0.54	0.31
Overall acceptability-acid value	-0.76	0.43
Overall acceptability-iodine value	-0.18	-0.06
Odor		
Odor- peroxide value	0.48	0.78
Odor- p-anisidine	-0.64	0.26
Odor- acid value	-0.76	0.21
Odor- iodine value	-0.81	-0.01
Flavor		
Flavor- peroxide value	0.42	0.78
Flavor- p-anisidine	-0.60	0.17
Flavor- acid value	-0.78	0.11
Flavor- iodine value	-0.21	-0.07
Taste		
Taste- peroxide value	0.59	0.57
Taste- p-anisidine	-0.75	0.01
Taste- acid value	-0.88	0.15
Taste- iodine value	-0.35	-0.33
Greasiness		
Greasiness - peroxide value	0.63	0.53
Greasiness - p-anisidine	-0.66	-0.66
Greasiness - acid value	-0.54	-0.75
Greasiness - iodine value	0.11	-0.64
Crispness		
Crispness - peroxide value	-0.22	0.03
Crispness - p-anisidine	0.38	0.61
Crispness - acid value	0.60	0.58
Crispness - iodine value	0.94	0.40

Note-*significant at $p<0.05$

PHASE III - RESULT HIGHLIGHTS

French fries

- *Significant increase ($p<0.05$) in various chemical parameters of CSO and GNO was observed as a result of intermittent frying of french fries up to 25 h.*
- *In terms of oxidation products i.e. peroxide value (PV), p-anisidine value (p-AV) and total oxidation products (Totox value-TV), CSO showed significant increase ($p<0.001$) than GNO during 25 h of intermittent frying.*
- *Iodine value (IV) of both the studied oils decreased significantly ($p<0.01$) with frying hours and a strong relation was observed between the duration of frying and IV of oils.*
- *French fries frying result in significant increase ($p<0.01$) in acid value (AV) of CSO and GNO during 25 h of intermittent frying. A strong relation was observed between duration of frying and AV.*
- *With regard to total polar components (TPC) increase from 1.9% and 1.1% to 11.5% and 10.6% was observed in CSO and GNO respectively at the end of frying duration. However, this increase in TPC of CSO and GNO was within the standard limit (<25%) set by European countries.*
- *Palmitic acid increased significantly ($p<0.01$) up to 16.4% and 11.8% in CSO and GNO respectively at the end of 25 h intermittent frying.*
- *Linolenic acid in GNO was totally missing with increased frying time (15 h). However, linolenic acid in CSO decreased significantly ($p<0.01$) up to 25 h of intermittent frying.*
- *18:2/16:0 ratio of GNO and CSO decreased by 33.8% and 25% respectively at the end of 25 h intermittent frying.*
- *Color and refractive index of CSO and GNO increased significantly ($p<0.001$) with the increase in frying duration.*

Bhajias

- *Significant increase ($p<0.001$) was observed in oxidation parameters (PV, p-AV and TV) of CSO and GNO* when *bhajias were fried intermittently up to 25 h.*
- *Bhajias fried in CSO showed significantly higher ($p<0.05$) values for PV, p-AV and TV than GNO during 25 h of intermittent frying. No correlation was found between PV and duration of frying.*
- *The IV of CSO was significantly ($p<0.05$) altered after 25 h of intermittent frying, indicating decrease in unsaturated fatty acids.*
- *The AV continued to increase in both CSO as well as in GNO significantly ($p<0.001$) up to 25 h of frying. Strong correlation was found between AV and duration of frying.*
- *TPC of CSO and GNO increased significant ($p<0.001$) at 25 h of intermittent frying.*
- *Saturated fatty acids (palmitic and stearic acid) of CSO did not increase when bhajias were fried intermittently up to 25 h. However, saturated fatty acids of GNO increased significantly.*
- *Oleic acid of CSO and GNO increased significantly ($p<0.05$) when bhajias were fried for 15 h intermittently.*
- *18:2/16:0 ratio of CSO decreased significantly ($p<0.01$) by 7% during 25 h of intermittent frying. Non significant decrease in 18:2/16:0 ratio was observed in GNO.*
- *Refractive index and color of bhajias fried oils increased as frying duration increased.*

DISCUSSION

In India, deep-fat-fried products form the major route through which oils and fats are consumed (Narasimhamurthy K and Raina PL, 1998). Deep fat frying is one of the oldest processes of food preparation and consists basically in the immersion of food pieces in hot oil. During frying, fat is subjected to hydrolysis, oxidation and polymerization that result in quality deterioration with respect to quality and nutritive quality of oil. The mechanisms of such processes are essentially the same in different fats; the rates at which different fats undergo deteriorative reactions vary. The choice of frying fat depends on many factors, such as availability, price, frying performance, and flavor. Frying oil acts as a heat transfer medium and contributes to the texture and flavor of fried foods (Choe E and Min DB, 2005).

Vegetable oil quality and stability are the main factors that influence consumer acceptability, market value and its health implications. Usually many oils can be used for frying e.g. palm oil, corn oil, cottonseed oil, soya oil, groundnut oil, sunflower oil etc.

Deep fat frying is normally carried out at high temperatures (between 160 and 180^{0}C) and in the presence of air and moisture, these frying oils and fats may undergo physical and chemical deteriorations that may affect the frying performance and stability of fried products (Choe E and Min DB, 2005). The most appropriate frying oil should be low in free fatty acids and polar compounds.

Deep fried foods are important food items in the diet and are widely available at street level from vendors. The necessity of using a good quality frying medium become obvious when one considered that some of the fat is absorbed by every piece of food fried in it. The overuse of deep-fried oil for frying may cause adverse effects on flavor, stability, color and texture of fried product and may be harmful to human health (Sulieman AERM, Makhzangy AE and Ramdan MF, 2006).

Several studies have been carried out to see the physico-chemical and sensory changes taking place in oil for prolonged frying hours (Xu Xin-Qing, 1999; Ryan LC et al, 2008; Warner K, Neff WE and Eller FJ, 2003; Warner K and Fher W, 2008).

Preliminary study regarding the frying practices in the households of Gujarat revealed that the Gujarati housewives do not deep fry the products for great length of time as reported by many studies. And therefore our study is focused on physico-chemical changes take place in deep fried oils and the sensory changes in the products fried in such oils for a shorter duration of frying time (total of 2.5 h /25 h of intermittent frying).

In the present study, CSO used for frying french fries and bhajias both, CSO showed less stability in terms of PV than GNO because oil containing higher amount of polyunsaturated fatty acids are more susceptible to oxidation than oils with higher monounsaturated fatty acids. Higher formation of peroxides in PUFA rich oils may be due to the lower activation energy, required by them in the initiation of free-radical formation (Tyagi VK and Vasistha AK, 1996).

PV of various oils have shown to vary during intermittent frying, study by Sulieman AERM, Makhzangy AE and Ramdan MF, 2006 showed that PV of cottonseed oil (1.9-33) was more than sunflower (1.7-28) and palm olein (1.6-10) when French fries were fried for 16 h of intermittent frying, indicating a greater extent of oxidation in cottonseed oil. Another study on comparative analysis of four vegetable oils namely mustard, groundnut, soybean and safflower oil revealed when potato chips were fried, PV increased maximum in the last two PUFA rich oils than MUFA rich oils (mustard and groundnut oil) (Sharma R et al, 2007).

In our study, bhajias fried in CSO and GNO shows less PV as compared to PV of respective oils used for frying french fries. Study conducted to observe the deterioration in oils used for frying different products showed, PV of frying medium used for frying cod fillets was 2 times lower than oils used for frying

sliced potatoes (Tynek M et al, 2001). Refined and partially hydrogenated (PH) rapeseed oil (RSO) was subjected to frying potato fritters, PV of refined and PH RSO increased from 0.6 to 8.87 and 0.0 to 10.3 meqO_2/kg of oil respectively (Hazuka Z et al, 2000).

PV of a blend of refined cottonseed oil: mustard oil (80:20) increased from 9 to 38 meqO_2/kg when *pooris* were fried for 6 h of continuous frying. This increase in PV of oil may possibly due to greater contribution of PUFA (80%) in oil blend (Premavalli KS, Madhura CV and Arya SS, 1998).

In the present study, peroxide values of oils showed rise and fall as the duration of frying increased. This is indication of instability of peroxides is also reported by Rani AKS, Reddy SY and Chetana R, 2010. This was in accordance with Farhoosh R and Moosavi SMR (2009) who stated parallel results when various vegetable oils were used for frying. Augustin MA and Berry SK (1983) indicated that use of PV for following the oxidative deterioration of fats and oils during deep-frying is problematic because peroxides are destroyed by heating temperature and during cooling new peroxides are formed.

As the regression equations of PV in the present study, it has been stated that during frying the changes in PV were not related to duration of frying, but may be dependent on rate of formation and breakdown of oxidation procedure (Sulieman AERM, Makhzangy AE and Ramdan MF, 2006).

Increase in p-AV of oil used frying may perhaps be explained by lipid oxidation of oils which is due to formation of unsaturated aldehydes during frying. In present study, p-anisidine values of CSO were higher than GNO at all intermittent intervals of french fries and bhajias frying. This is because higher p-anisidine values of CSO rich in PUFA more prone to oxidation than GNO (MUFA). Similar findings have been reported by Ryan LC et al (2008), when sunflower, corn, and soybean oil (PUFA rich oils) fried discontinuously up to 96 h showed higher increment in p-AV as compared to peanut and olive oil (MUFA). Another study by Das AK et al (2011) reported significant increase in p-anisidine values of GNO from 8.99 to 172.4 during intermittent

frying and increased from 8.99 to 133 at the end of continuous frying of *pooris*. Further, when potato fritters were fried in refined rapeseed oil for continuous 9 days (15 cycles each day), p-AV increased from 3.8 to 186 (Hazuka Z et al, 2000).

Difference in p-AV of oil used for frying french fries and bhajias has also been observed in the present study. Similarly, frying of cod fillets in rapeseed oil (RSO) showed smaller increase in p-AV as compared to RSO used for frying potato slices (Tynek M et al, 2001).

p-AV of CSO and GNO in the present study shows a strong relation with frying duration. Study on frying of rice flakes in crude red palm oil (CPO), and its blend with sunflower and groundnut oil showed increase in p-AV with increased heating and frying regimen (Goyal N and Sundararaj P, 2009). On the contrary when canola oil was used for frying at higher temperatures (215^{0}C) p-AV was not well correlated with duration of frying (Aladedunye FA and Przybylski R, 2009).

Intermittent frying results in progressive decrease in unsaturation of both the oils, whereas decrease in iodine value (IV) of CSO was much faster than GNO. Many researchers have shown similar results when soybean oil rich in unsaturated fatty acids was used as frying medium had faster loss of unsaturation than *vanaspati*, partially hydrogenated canola and palm olein oils (Tyagi VK and Vasistha AK, 1996; Xu XQ et al, 1999). It has been observed that thermal oxidation and degradation of oils, results decrease in unsaturated fatty acids content and hence rapid decrease in iodine value.

Both CSO and GNO showed a considerable decrease IV when used for frying french fries and bhajias. However, the decrease was well within the suggested limits set by vegetable oil products order, 1998. Study by Baixauli R et al (2002) observed continuous decrease in IV of high oleic refined sunflower oil when batter coated squid rings were fried intermittently. Other studies have also reported decrease in IV of sunflower oil, *vanaspati*, bakery shortening and rapeseed oil used for frying *chiroti* (refined wheat flour made deep fried

product) and french fries respectively (Rani AKS, Reddy SY and Chetana R, 2010; Kita A, Lisinska G and Powolny M, 2005).

The possible reason for reduction in IV of oil used for frying purposes may be due to removal of hydrogen adjacent to the double bond, oxidation, scission, and polymerization (Tyagi VK and Vasistha AK, 1996).

Acid value (AV) and total polar components (TPC) indicators of chemical deterioration of oil showed little changes in CSO and GNO when french fries and bhajias were intermittently fried for 25 h. Initial AV and TPC values of both the oils was in recommended limit set by Vegetable oil products order (1998) and European countries.

In both french fries or bhajias frying, higher increase in AV was noticed in CSO at all frying intervals. A comparative study on frying stability of sunflower, mustard, groundnut oil showed more stability than *desi ghee* and *vanaspati* in terms of AV (Kaur A, Hira CK, and Raheja RK, 1997). It has been observed that AV of oil is affected by the type of frying oil and the type of food being fried (Melton SL et al, 1994).

In the present study, bhajias fried in CSO and GNO showed lesser AV than french fries fried oils. This may be due to presence of salt which cause additional denaturation of proteins, which may lead to the appearance of new junction points for the formation of bonds with COOH groups in the fatty acids (Llorca E et al, 2003). AV of the oils in our study increased significantly during frying and was strongly related with duration of frying, supporting similar trend of the previous studies (Xu Xin-Qing et al, 1999; Farag RS, Farag MM and Ali RFM, 2008). Although in each case it did not reach to the discarding limit (>2.5) set by EU (Xu Xin-Qing, 1999).

In the present study TPC was steadily increased in both the oils (CSO and GNO) with frying duration. Present results are in accordance with the other studies findings that TPC increase with the frying duration (Romero A, Cuesta C and Sanchez-Muniz FJ, 1998; Normand L, Eskin NAM and Pryzbylski R, 2001; Aladedunye FA and Pryzbylski R, 2009). This increase in

TPC may possibly be due to thermo oxidative alteration in oils during the experimental period of frying.

As TPC is a good indicator of frying oil quality, and frying oils with 25-27% TPC content have deteriorated to the point where they should be discarded (White PJ, 1991). To reach to the discarding limit (25%), Razali I and Badri M (2003) revealed, it took 3 days when frozen french fries were intermittently fried in palm oil, palm olein, soybean or hydrogenated oil at 180^{0}C for 4 minutes per batch for a total frying period of 8 hours a day, over 5 consecutive days.

Present findings showed, irrespective of the type of products fried, CSO had significantly higher TPC than GNO thus indicating less stability of PUFA. In 2002, Sanchez-Muniz FJ and Bastida S reported that during the initial 20 h of discontinuous frying operations polar components increased more intensively, mainly in sunflower oil than olive oil and their blend. In another study, when wheat flour dough containing egg yolk powder was repeatedly fried in sunflower oil it was found contents of polar compounds formation increased upon repetition of frying (Kim H and Choe E, 2008).

Change in fatty acid profile of oil during frying was observed in the present study also. As a result of frying many changes occurred because of cyclization, polymerization, pyrolytic, oxidative, hydrolytic and other chemical changes promoted by frying conditions (Tyagi VK and Vasistha AK, 1996).

Alteration in saturated fatty acids (SAFA) during frying was significant in both the oils irrespective of the products fried in them. Palmitic (C16:0), and stearic (C18:0) of CSO and GNO was increased in both the oils as the frying duration increased. Houhoula DM, Oreopoulou V and Tzia C (2002) showed increase in saturated fatty acids of refined cottonseed oil during 12 h of intermittent frying. Study by Aladedunye FA and Przybylski R (2009) showed similar results, during frying of canola oil at 185^{0}C.

Monounsaturated fatty acid (oleic acid; C18:1) concentration in CSO and GNO was increased when french fries were fried in the present study. This

unusual increase in oleic acid was also observed by Sulieman AERM, Makhzangy AE and Ramdan MF, (2006); Toliwal SD and Tiwari MR (2008), explaining the migration of fatty acid from foods being fried into the oil could be the possible reason.

The results show generally that, in both (CSO and GNO) the frying mediums, there were decrease in polyunsaturated fatty acids (C18:2 and C18:3). Linoleic acid (C18:2) in both the oils decreased in considerable amount when french fries and bhajias were fried intermittently up to 25 h. Linolenic acid (C18:3) in GNO was totally missing at 15 and 25 h of french fries and bhajias frying. Similarly, Tyagi VK and Vasistha AK (1996); Aladedunye FA and Przybylski R, 2009 and Tynek M et al (2001) also reported losses in triene content (C18:3) was much higher than monoenes (C18:1) and dienes (C18:2). Polyunsaturated fatty acid (PUFA) rich oil degraded much faster because of lipid oxidation (Nzikou JM et al, 2009). This decrease in both the studied oils signifies that heat treatment of fats induces alteration of fatty acids with two or three double bonds. In the current study the level of PUFA tended to decrease, whereas that of SAFA increased.

Studies suggested decrease in linoleic acid to palmitic acid ratio (18:2/16:0) as a convincing indicator of PUFA deterioration (Houhoula DM, Oreopoulou V and Tzia C, 2002; Aladedunye FA and Przybylski R, 2009). Present study also showed a similar decrease in 18:2/16:0 ratio of CSO and GNO when french fries and bhajias were fried up to 25 of intermittent frying.

Physical parameters of the studied oils i.e. refractive index and color increased significantly with the frying time. Different studies showed increase in RI of oils after frying, auto and photo oxidation (Tyagi VK and Vasistha AK, 1996; Raza SA et al, 2009). Study showed similar pattern of increase in refractive index of oil, when *pooris* were fried in blend of cottonseed and mustard oil (Premavalli KS, Madhura CV and Arya SS, 1998).

Change in color of oil when french fries and bhajias were fried was a result of browning during frying, attributed half to the amino-carbonyl reaction

between amino acids and carbonyl compounds generated from oil or presence of certain compounds could possibly be the other reason (Totani N et al, 2006; Narasimhamurthy K and Raina PL, 1998).

Our study had showed a significant increase in color of oil, this can be due to food fried had plenty water at ambient temperature are put in heated oil, numerous bubbles are formed, resulting in drastic oxidation of the oil due to great increases of oil surface (Totani N et al, 2007). In a study by Ogunsina BS et al in 2011 showed 52% increase in color intensity of refined groundnut oil when potato slices were fried in 10 repeated successions spanning a total time of 2 h. Rise in color intensity of fried oils is indicative of increase in its oxidation (redder the oil, the more oxidized it is) thus reducing its stability (Hack DM, Bordi PL and Hessert SW JR, 2009).

To conclude, thermal-oxidation of GNO and CSO was noticed at 5 h of intermittent frying as indicated by rise in PV and p-AV beyond the acceptable limits. In terms of acid value and iodine value, CSO showed less stability than GNO and crossed the standard limits. Considering deteriorative factor fatty acid profile in fried oils, linolenic acid went totally missing in GNO when french fries and bhajias were fried in it. Decrease in 18:2/16:0 ratio was greater in CSO than GNO when french fries and bhajias were intermittently fried for 25 h.

PHASE IV

5.4: CASE STUDY ON PREVAILING FOOD SAFETY AND FRYING PRACTICES IN JAN AAHAR- A GOVERNMENT RUN FOOD OUTLET AT VADODARA RAILWAY STATION

The health and the nutritional status of the people, depends to a large extent on the quality of food they eat. It is therefore essential to ensure that the food they consume is safe and wholesome. Safe food may be defined as, "a product which contains no physical, chemical or microbiological organisms or by products if consumed by man will result in illness, injury or death-an unacceptable consumer health risk" (Stier 2000). FDA (2004) and MOH (2001) have outlined five risk factors that need to be evaluated and assessed in complying with safe food preparation. They are safe food sources, food storing temperature and stock control, personal hygiene practice, cross contamination and safe temperature of holding food.

Apart from the microbial safety of foods, chemical changes in food during processing needs to be looked upon for their nutritional safety. Agreements in the form of legislation must be put in place in order to ensure that safe and healthy food reaches consumers.

Thus, the IV phase of present study was designed to determine the current food safety and frying practices prevailing at the Government run food outlet Jan aahar at Vadodara railway station particularly with respect to use of oils.

The results of this phase are presented under the following heads:

5.4.1: General information and hierarchy of Jan aahar-a food joint at Vadodara railway station

5.4.2: General information of staff members working at Jan aahar

5.4.3: Knowledge on food hygiene, nutrition and health and personal hygiene of kitchen staff at Jan aahar

5.4.4: Observed practices of cooks, cleaners and waiters on personal hygiene

5.4.5: Observed practices on food hygiene, environmental hygiene and unit hygiene

5.4.6: Oil procurement and storage and frying practices

5.4.1: General information and hierarchy of Jan aahar- a food joint at Vadodara railway station

Jan aahar was established in May 2009 at western zone railway station-Baroda. Jan aahar is managed by railway staff. It was taken over from IRCTC (Indian Railway Catering and Tourism Corporation) in June 2011, due to mass complaints regarding quality of food and services. Railway ministry has decided to provide health foods to the passengers at cheaper rates approved by Indian railways. Jan aahar is currently running in loss at the rate of 2 laks 40 thousand per month.

All food handling staff has their medical fitness certificate from Railway doctor every year. Fixed amount of ration is provided by Railways to food outlet. Accounting of the sales is being checked by accounts department of railways on day to day basis. Raw materials are purchased from local market by purchasing committee assisted by 1 commercial officer, 1 accounts officer and 1 medical officer. Quality and rates of the purchased products is checked by the purchasing committee. Cleanliness of the premises is maintained by cleaners twice a day. Food preparation is carried out daily 3 times a day and approximately 250 customers make use of this outlet. The daily income is about Rs. 3500. Figure 5.4.1 shows the hierarchy of Jan aahar kitchen staff.

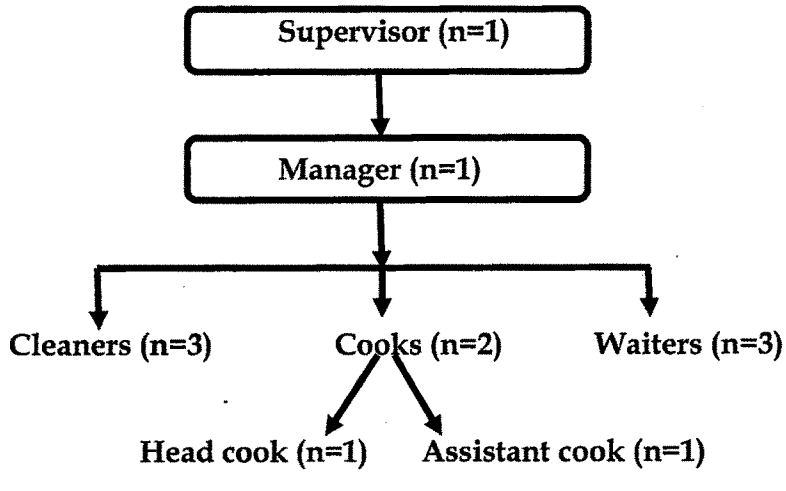


Figure 5.4.1: Hierarchy of Jan aahar kitchen staff

5.4.2: General information of staff members working at Jan aahar

Table 5.4.2 shows general information of the staff members working at Jan aahar. A total of 10 members are presently working in kitchen. It was found that manager was educated up to graduation. However, 2 staff members were found illiterate indicating 20% illiteracy. Out of 10 staff members only 4 staff members were trained in food safety. Majority of food handlers were in the age group of 31-45 year. All the kitchen staff at Jan aahar work for 8 hours in two shifts.

Table 5.4.2: General information of staff members working at Jan aahar

Work doing	Education	Age	Food safety training Yes/No
Supervisor	Graduate	58	Yes
Manager	Graduate	47	Yes
Head cook	Illiterate	57	Yes
Asst. cook	Primary	58	No
Cleaner 1	Primary	28	No
Cleaner 2	Primary	55	No
Cleaner 3	Primary	56	No
Waiter 1	Illiterate	60	No
Waiter 2	High school	50	No
Waiter 3	High school	50	Yes

5.4.3: Knowledge on food hygiene of kitchen staff at Jan aahar

The knowledge scores on food hygiene of kitchen staff working at Jan aahar at Vadodara Railway Station is shown in Table 5.4.3.1. F-test on food hygiene knowledge scores of all the kitchen staff showed no significant difference. However, supervisor gained maximum score (85%) on food hygiene knowledge amongst all the other kitchen staff. Cleaners and waiters showed 62-80% food hygiene knowledge. Amongst the various aspects of food hygiene knowledge, correct way to manage leftover food was fairly known (52%) by all the kitchen staff with excellent (90%) scores obtained for knowledge on characteristics of spoiled food.

Knowledge scores on nutrition and health of Jan aahar kitchen staff is shown in Table 5.4.3.2. A significant difference ($p<0.05$) was observed amongst the knowledge scores of kitchen staff. Waiters and assistant cook obtained lowest scores 22-27% (poor) on nutrition and health respectively as compared to other staff with manager scoring the highest (69%). Amongst the various aspects of nutrition and health studied, most staff had excellent knowledge on food adulterants followed by ways to conserve nutrients while processing and cooking. Poor knowledge was exhibited by most workers at Jan aahar on aspects such as nutrients essential for growth, sources of protein, vitamins, minerals, value addition of foods and harmful effects of excessive heating of oil.

Table 5.4.3.3 shows the personal hygiene knowledge scores of Jan aahar kitchen staff. F-test showed a significant ($p<0.01$) difference amongst personal hygiene knowledge scores of Jan aahar kitchen staff. Excellent scores were obtained by maximum kitchen staff and only one waiter scored poorly for personal hygiene. Excellent scores (85-100%) for individual personal hygiene practices were obtained by all the staff members. Individual personal hygiene practice i.e. activities after which hand wash with soap is must, scored 100% by the kitchen staff.

Table 5.4.3.1: Knowledge scores on food hygiene aspects of kitchen staaf at Jan aahar

Food Hygiene aspects	Supervisor	Manager	Cook	Asst. cook	C 1	C 2	C 3	W 1	W 2	W 3	Total	% score	Individual knowledge score grades
4 food borne illnesses	3	2	3	2	2	1	2	3	3	4	25	62.5	Good
4 characteristics of spoiled food	4	4	4	3	4	3	4	3	4	4	37	92.5	Excellent
4 symptoms of food borne illness	4	4	4	2	3	4	4	4	2	4	35	87.5	Excellent
4 ways to prevent bacterial contamination while handling	3	4	4	4	3	4	4	3	3	3	35	87.5	Excellent
4 food contaminants which make food unsafe and unfit for consumption	4	3	3	3	3	4	4	2	3	4	33	82.5	Excellent
4 biological sources of food contamination	4	3	4	4	4	3	4	4	4	4	36	90	Excellent
4 ways to manage leftover food	3	2	2	3	2	1	0	2	3	3	21	52.5	Fair
4 ways of serving safe drinking water	3	2	3	3	3	2	2	2	3	3	26	65	Good
4 reasons to store raw material at dry place	3	3	4	1	3	4	2	2	4	4	30	75	Very good
4 reasons to cover cooked food	3	3	2	3	3	3	3	2	3	4	29	72.5	Very good
Total	34	30	33	28	30	29	29	25	32	37			
% score	85	75	82.5	70	75	72.5	72.5	62.5	75	80			
Staff grades	Excellent	Very good	Excell -ent	Very good	Very good	Very good	Very good	Good	Very good	Very good			
F-test-					1.57^{NS}								

Note: NS- not significant; 0-No response, 1-Unsatisfactory score, 2- Average score, 3- Satisfactory score, 4-Most satisfactory score; C-Cleaner; W-Waiter

Grade classification- Above 80-excellent; 70-80- very good; 60-69- good; 50-59- fair; less than 50- poor

Table 5.4.3.2: Knowledge scores on nutrition and health aspects of kitchen staff at Jan aahar

Knowledge on nutrition and health aspects	Supervisor	Manager	Cook	Asst. cook	C 1	C 2	C 3	W 1	W 2	W 3	Total	% Scores	Individual knowledge score grades
4 energy foods	3	3	3	2	3	2	2	2	1	2	23	57.5	Fair
4 ways to conserve nutrients while processing and cooking food	3	4	4	3	3	4	2	4	3	2	32	80	Very good
4 nutrients essential for growth and maintenance	1	4	2	0	0	0	0	0	0	0	7	17.5	Poor
4 food sources of protein	3	4	2	0	0	3	0	0	0	0	12	30	Poor
4 rich sources of vitamins	2	2	1	0	0	2	2	0	0	0	9	22.5	Poor
4 food adulterants	4	3	4	3	3	4	4	4	4	4	37	92.5	Excellent
4 sources of minerals	2	1	2	0	0	2	0	0	0	0	7	17.5	Poor
4 ways for value addition of the food products	0	0	0	0	3	2	0	0	0	0	5	12.5	Poor
4 harmful effects of excessive heating of oil	4	4	1	0	2	0	2	0	1	1	15	37.5	Poor
Total	22	25	19	8	14	19	12	10	9	9			
% Scores	61	69.4	52.7	22.2	38.8	52.7	33.3	27.7	25	25			
Staff grades	Good	Good	Fair	Poor	Poor	Fair	Poor	Poor	Poor	Poor			
F-test-					1.93*								

Note: *-significant at p<0.05, 0-No response, 1-Unsatisfactory score, 2- Average score, 3- Satisfactory score, 4-Most satisfactory score; C-Cleaner; W-Waiter

Grade classification- Above 80-excellent; 70-80- very good; 60-69- good; 50-59- fair; less than 50- poor

Table5.4.3.3: Knowledge scores on personal hygiene of kitchen staff at Jan aahar

Personal Hygiene	Supervisor	Manager	Cook	Asst. cook	C 1	C 2	C 3	W 1	W 2	W 3	Total	% Scores	Individual knowledge score grades
4 protective clothes necessary for a food handler	4	4	4	3	4	3	4	0	4	4	37	92.5	Excellent
4 bad habits which should be prohibited by food handlers	4	4	4	3	4	3	3	0	4	4	34	85	Excellent
4 activities contaminate food with harmful germs	4	4	4	4	4	4	4	0	4	4	36	90	Excellent
4 activities after which hand wash with soap is must	4	4	4	4	4	4	4	4	4	4	40	100	Excellent
Total	16	16	16	14	16	14	15	8	16	16			
% Scores	100	100	100	87.5	100%	87.5%	93.8%	50%	100%	100%			
Staff grades	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent			
F-test-						3.6**							

Note: **-significant at p<0.01, 0-No response, 1-Unsatisfactory score, 2- Average score, 3- Satisfactory score, 4-Most satisfactory score; C-Cleaner; W-Waiter

Grade classification- Above 80-excellent; 70-80- very good; 60-69- good; 50-59- fair; less than 50- poor

5.4.4: Observed practices of cooks, cleaners and waiters on personal hygiene

Cooks, cleaners and waiters were observed for practices such as wearing of protective clothes, their appearance, refraining from habits such as gutka eating, tobacco chewing, use of clean hand towels and clean nails. Based on the observation they were given a score of 3 for every satisfactory practice, 2 for average practice and 1 for unsatisfactory practice.

Table 5.4.4 reveals that there was no significant difference on observed personal hygiene practices of cooks, cleaners and waiters. The personal hygiene of cooks was poorer (48%) than other workers namely cleaners and waiters who scored better in the range of 63-70%. Except for assistant cook, all the staff of Jan aahar refrained from practices such as gutka eating and tobacco chewing. All the workers undertook a regular health check up. With regards to protective clothing none of the worker wore uniforms, head gears and gloves. No hand towels were used by the workers for wiping hands and a dirty linen was used after multiple activities including wiping hand after hand washing.

Table 5.4.4: Observed personal hygiene practices of cooks, cleaners and waiters at Jan aahar

Personal Hygiene	Cook	Asst. cook	C1	C2	C3	W1	W2	W3	Total	% scores	Individual knowledge score grades
The food handlers have uniform, head gear, apron and towel	1	1	1	1	1	2	2	2	11	34.4	Poor
Overall appearance of food handlers is clean	1	1	2	2	2	2	2	2	14	43.8	Poor
Washing with soap after toilet/personal work	2	2	3	3	1	1	2	2	16	50	Fair
Dresses of the employees are clean	2	2	2	2	2	3	3	2	18	56.3	Fair
Nails of the workers are clean	1	1	2	2	3	3	2	1	15	46	Poor
No smoking, gutka eating and tobacco chewing by the staff while working	3	1	3	3	3	3	3	3	22	68.8	Good
Dry hands with separate towel/napkins for the same	1	1	2	2	1	1	1	1	10	31.2	Poor
Use of mask while cooking and serving	1	1	1	1	1	1	1	1	8	25	Poor
Whether health check up was done before or during service	3	3	3	3	3	3	3	3	24	100	Excellent
Total	15	13	19	19	17	19	19	17			
% scores	55.5	48.1	70.3	70.3	62.9	70.3	70.3	62.9			
Staff grades	Fair	Poor	Very good	Very good	Good	Very good	Very good	Good			
F-test-					0.77^{NS}						

Note: NS-non significant, 1-Unsatisfactory score, 2- Average score, 3- Satisfactory score; C-Cleaner; W-Waiter

Grade classification- Above 80-excellent; 70-80- very good; 60-69- good; 50-59- fair; less than 50- poor

5.4.5: Available infrastructure facility on food hygiene, unit hygiene and environmental hygiene at Jan aahar

Satisfactory food hygiene practices shown in Table 5.4.5 (a), were observed for sorting of grains, removal of unwanted portion, use of clean knives, use of refrigerator for storage etc. However, practices such as adequate washing of vegetables, covering of foods after cooking and labeling of foods was found to be unsatisfactory.

With respect to unit hygiene it was observed that the service counters were not cleaned frequently and the washbasin appeared dirty. However, the kitchen floor was mopped after every shift. Further, satisfactory environmental hygiene was observed such as dining area was clean and free from flies and insects, daily use of disinfectants and no human disposal near the restaurant.

Regarding the observed infrastructure facilities available at Jan aahar, it can be seen in Table 5.4.5 (b) that satisfactory scores were obtained for amenities like use of stainless steel knives, commercial detergents for washing utensils, glazed kitchen top, floor, running tap water facility, use of smokeless fire and fuel for cooking, white wash of walls, roof, store, kitchen etc. However, facilities found to be average and unsatisfactory include clean cloth was not present for moping tables, counters; no soap and clean towel was present at washbasin, not availability of geyser for washing utensils, no separate store for raw materials and the kitchen had no ventilators and chimney indicating a further need of improvement in the studied catering joint.

Table 5.4.5 (a): Observed practices of available infrastructure facility on food hygiene, unit hygiene and environmental hygiene in Jan aahar

(a) Practices	Unsatisfactory	Average	Satisfactory
Food hygiene			
Use of running water for washing of raw materials			3
Sorting and removal of unwanted portion, ingredient before cooking and processing		2	
Chopping and peeling only after proper washing	1		
Use of clean knifes, cutter and chopping board for vegetables, salads		2	
Every item is covered before cooking, during cooking and after cooking	1		
Spices, food ingredients were clean and labeled	1		
Use of chilling facilities/refrigerator for storage		2	
Cooked food was stored in stainless steel vessels		2	
All serving and dining vessels were covered and kept at a dry place		2	
Running water was provided for washing and cooking			3
Total score			
% score	**3**	**10**	**6**
Unit hygiene	**30**	**50**	**20**
Utensils are washed immediately after use			3
Presence of neat and clean wash basin	1		
Service counter was cleaned frequently	1		
Washing and mopping of floor after every shift			3
Total	**2**	**0**	**6**
% score	**50**	**0**	**50**
Environmental hygiene			
Dining table and hall is free from flies and insects			3
Surrounding are clean and free from flies and insects			3
Daily use of disinfectant for cleaning of surrounding			3
Facility for driving pets out		2	
No animal/human disposal near restaurant			3
Total	**0**	**2**	**12**
% score	**0**	**20**	**80**

Table 5.4.5 (b): Observed available infrastructure facilities in Jan aahar

(b) Infrastructure facility	Unsatisfactory	Average	Satisfactory
The restaurants had separate store for raw materials		2	
Use of stainless steel knives			3
Commercial detergents are used for washing utensils			3
Clean cloth is used for moping of tables, counters etc.	1		
Wash basin has running tap water facility			3
Wash basin has soap/liquid soap	1		
Wash basin has clean and dry towels	1		
Food service unit is dust, dirt and smoke free	1		
Use of smokeless fire and fuel for cooking			3
The kitchen had exhaust fan, ventilators and chimney		2	
Hot water/ geysers facility is available	1		
Water purifier facility was provided for drinking water	1		
Service counter had glazed surface	1		
Detergent and tools used for washing of kitchen top, ground floor, sinks, stores etc. after every shift			3
White wash of walls, roofs, stores, kitchen etc.			3
Dining place covered, ventilated and lighted			3
No garbage near the restaurant			3
Disposal of garbage in waste bins having proper lids	1		
Total	**8**	**4**	**24**
% score	**44.4**	**11.1**	**44.4**

5.4.6: Oil procurement, storage and frying practices at Jan aahar

Cottonseed oil was used by cooks for frying and other cooking purposes. Cooking oil was procured in jerry cans from wholesale shops of Vadodara. Twenty liters oil was purchased at a time which lasted for 5 days. Cooking oil was stored at open area of kitchen. As told by the head cook and asst. cook, loose oil was not purchased due adulteration. Before purchase of cooking oil, expiry date of oil was monitored as told by the cooks, however they did not know the shelf life of packed oil.

Frying practices of cooks: Frying practices of cooks was assessed as shown in Table 5.4.6. It found that both the cooks did not know the correct frying temperature and had no idea how to measure frying oil temperature. Iron and hindalium vessels were used for frying food products as reported by both the cooks. Frying vessels were cleaned daily with hot water and dish cleaning soap. Both the cooks had good knowledge about the deterioration of oil quality such as foaming, color change, change in consistency of fried oil. Cooks reported that fried food particles from oil were removed before every frying. Leftover fried oil was filtered, not reused for frying purpose and was stored in stainless steel jars for other purposes like sautéing.

Table 5.4.6: Frying practices of cooks at Janaahar- a food joint at Vadodara railway station

Practices	Head cook	Asst. cook
a) Have you ever measured frying temperature? Yes/No	No	No
b) Are you aware of correct frying temperature? Yes/No	No	No
c) If yes, what is the correct frying temperature? i)100^{0}C ii) 160^{0}C iii)180^{0}C iv) 250^{0}C	--	--
d) Do you know how frying temperature is measured?	Do not know	Do not know
e) What type of frying vessel is used for frying? i) Iron ii) Stainless steel iii) Hindalium	Iron	Iron
f) How often you clean you frying vessel? i) Daily ii) 2-3 times a week iii) Once a week iv) After a week, specify	Daily	Daily
g) Do you know how frying vessel should be cleaned? Yes/No	Yes	Yes
h) If yes, how? i) with water only ii) with water and dish cleaning soap iii) with water and caustic	With hot water and dish cleaning soap	With hot water and dish cleaning soap
i) Do you know change in color is an indicator of deterioration of oil quality? Yes/No	Yes	Yes
j) Do you know foaming in is an indicator of deterioration of oil quality? Yes/No	No	No
k) Do you know change in consistency is an indicator of deterioration of oil quality? Yes/No	Yes	Yes
l) Is the presence of food particles in fried oil is an indicator of deterioration of oil quality? Yes/No	Yes	No
m) What do you do with food particles in oil? i) separate them from oil before frying every time ii) do not separate them from oil and fry in same oil	Separate them from oil before frying every time and throw them	--
n) Do you add fresh oil in fried oil? Yes/No	No	Yes
o) One batch of oil should be fried for how many hours? i) 2 h ii) 4 h iii) 8 h iv) More	8 hours	8 hours
p) Do you store leftover fried oil? Yes/No	Yes	Yes
q) If yes, in which utensil i) Same pan in which the food was fried ii) Plastic container iii) Stainless steel jar iv) Other utensil	--	Stainless steel jar
r) Practice of storing fried oil i) Filtered ii) Without filter	Filtered	Filtered

PHASE IV - RESULT HIGHLIGHTS

- *Jan aahar, a catering outlet is situated at western zone railway station-Baroda.*
- *Jan aahar caters approximately 250 customers daily. Currently it is running in loss at the rate of 2 laks 40 thousand rupees/month.*
- *A total of 10 kitchen staff members are presently working and only 4 members have gone through with food safety training.*
- *Food hygiene knowledge of Jan aahar kitchen staff showed no significant difference. However, supervisor, manager and head cook scored maximum for food hygiene.*
- *Amongst the various aspects of food hygiene knowledge, correct way to manage leftover food was fairly known (52%) by all the kitchen staff.*
- *A significant difference ($p<0.05$) was observed amongst the knowledge scores on nutrition and health of kitchen staff. Waiters and assistant cook obtained lowest scores 22-27% (poor) on nutrition and health respectively as compared to other staff with manager scoring the highest (69%).*
- *Poor knowledge was exhibited by most workers at Jan aahar on various aspects of nutrition and health.*
- *Significant ($p<0.01$) difference amongst personal hygiene knowledge scores of Jan aahar kitchen staff.*
- *Excellent scores (85-100%) for individual personal hygiene practices were obtained by all the staff members.*
- *No significant difference was observed on personal hygiene practices of cooks, cleaners and waiters.*
- *Except unit hygiene, satisfactory food hygiene and environmental hygiene was observed. Infrastructural facilities like clean cloth, moping cloth for tables, counters, geyser for washing utensils, separate store for raw materials etc. were lacking.*
- *Both the cooks did not know the correct frying temperature. Although cooks had good knowledge about the deterioration of oil quality during frying.*

DISCUSSION

The nutritional status, health, physical and mental faculties depend on the food we eat and how we eat it. Access to good quality food has been man's main endeavor from the earliest days of human existence. Safety of food is an inherent component of food quality.

Food joints such as restaurants, street food vendors, *dhabas*, fast food joints, railway and bus stand food outlets have come to stay in today's contemporary world, due to increased need for food outside home, be it for people who are migrating for educational purpose or for other purposes and are considered as an important source of food borne outbreaks. Unhygienic preparation of food in such places provides ample opportunities for contamination, growth, or survival of food borne pathogens that may lead to diseases commonly referred as food borne illness. According to Mazumdar S (1992) 40% of the food borne illness is caused by mishandling of food and cross contamination in catering establishments.

People have the right to accept the food they eat to be safe and suitable for consumption. The importance of safe food for health and development has been recognized and addressed in many international fores as well. Safe food is one of the three essentials for maintenance of life and health. "Food safety" implies absence of biological contaminants, adulterants, naturally occurring toxins or any other substance beyond safety limits and that, which may make food injurious to health on an acute or chronic basis.

In view of above, the present work was undertaken to study the food safety knowledge of kitchen staff and practice of kitchen staff with respect to food hygiene, personal hygiene, unit hygiene etc. at Jan aahar-a food joint at Vadodara railway station.

The present study revealed that knowledge on food hygiene of kitchen staff at Jan aahar was excellent for most studied aspects. This could be because of food safety training taken by the senior kitchen staff working at Jan aahar. According to WHO, the most important cause of the spread of food borne

disease is the poor knowledge on food safety and unhygienic methods adopted by food handler. In order to prevent the food disease outbreaks food safety education to food handlers should be imparted. A study on the knowledge, attitude and practices of food service staff regarding food hygiene in Iran reported that the personnel had little knowledge regarding pathogens that cause food borne diseases and the correct temperatures for the storage of hot or cold ready to eat food (Askarin M et al, 2004).

With regards to personal hygiene knowledge maximum kitchen staff gained excellent scores. However, the observed personal hygiene of most staff was not satisfactory. Study by Olsen et al found that annually from 1993 to 1997, poor personal hygiene of food workers was a contributing factor in 27 to 38% of food borne illness outbreaks. Difference in knowledge and observation scores in the present study may perhaps due to lack of interest in following the food safety rules or ignorance could be the other reason. Study by Sheth M, Gupta A and Ambegaonkar T in 2011 reported personal habits of unsupervised food handlers working in a restaurant was poor where the staff resorted to tobacco chewing and eating beetle leaf and/or beetle nut and habit of smoking. Such unhygienic practices may introduce a variety of micro organisms in food (Kudu and Mishra, 2003). Present study has revealed better personal hygiene of Jan aahar staff than the above reported study. This could be because of good control by the supervisor at Jan aahar. In another study by Sheth M, Sukul S and Patel R (2007) reported that majority of the kitchen staff working in University Boy's hostel of Vadodara city, India, had poor personal hygiene with regard to dirty nails and moustache.

Knowledge on nutrition and health aspects of Jan aahar kitchen staff was poor indicating a need for proper training on this aspect. In a study undertaken to train street food vendors on food safety with a component of nutrition and health showed very good knowledge on nutrition and health prior to the training which improved significantly after the training (Sukul S and Sheth M, 2010). Nutrition and health component of kitchen staff of most kitchen food services establishments is found to be very poor. However,

training imparted on this aspect improved their knowledge on nutrition and health (Malhotra R et al, 2008; Meer RR and Misner SL, 2000; Cox et al, 2003).

The infrastructure facility of Jan aahar was found unsatisfactory in many aspects and hence is a cause of concern from food safety point of view. WHO report on survey of street vended foods revealed that the most critical problems in street vending is provision of infrastructural facilities like supply of safe drinking water, sufficient quantity of water for washing, cleaning and other operations. WHO (1996), reported that countries under study had limited infrastructure developments with restricted access to potable water (47%), toilets (15%), refrigeration (43%) and washing and waste disposal facilities.

Regards to oil procurement and frying practices, satisfactory responses were obtained by the cooks of Jan aahar. In a cross-sectional survey on food outlet operators (n=100) of Kuala Lumpur showed that food operators had moderate (53%) knowledge regarding usage of repeated heated cooking oil their detrimental effects on health (Azman A et al, 2012). In addition, a recent Indian study by Goyal N and Sundararaj P (2009) has shown the use of abused oil being used by many restaurants and food outlets. However, in the present study, cooks at Jan aahar did not reuse the oil for frying.

Hence, the present work has thrown light on existing infrastructure facility of Jan aahar and the knowledge levels and practices of the staff of Jan aahar on various food safety aspects. With a regular food safety training program the knowledge level of the staff can be improved. The railway ministry needs to work on improving the infrastructure facility.

PHASE V

5.1: DEVELOPMENT OF NUTRITION HEALTH EDUCATION (NHE) MATERIAL IN TWO LANGUAGES ON INTAKE OF EDIBLE OIL, TYPES, AND ON CHOICES OF OILS FOR HEALTHY LIVING AND PROBLEMS DURING FRYING OF EDIBLE OIL AND ITS STORAGE.

"Health education or communication (HE/C), i.e., interpersonal or mass communication activities focused on improving the health of individuals and populations" (Nutbeam D, 1998) has emerged as a positive way to educate people on important health issues. Review article by Ishikawa H and Kiuchi T (2010) stated that according to US Healthy People 2010 project, dissemination of individual and population health risk information is under the risk communication and construction of public health messages may contribute to disease prevention and health promotion.

In present phase of the study NHE was developed to educate people about edible oil recommended intake, sources, storage, correct practices of frying and calorie content of common fried foods.

This phase was divided under the following heads:

5.5.1: To develop IEC material on edible oil, types of oil, and its composition.

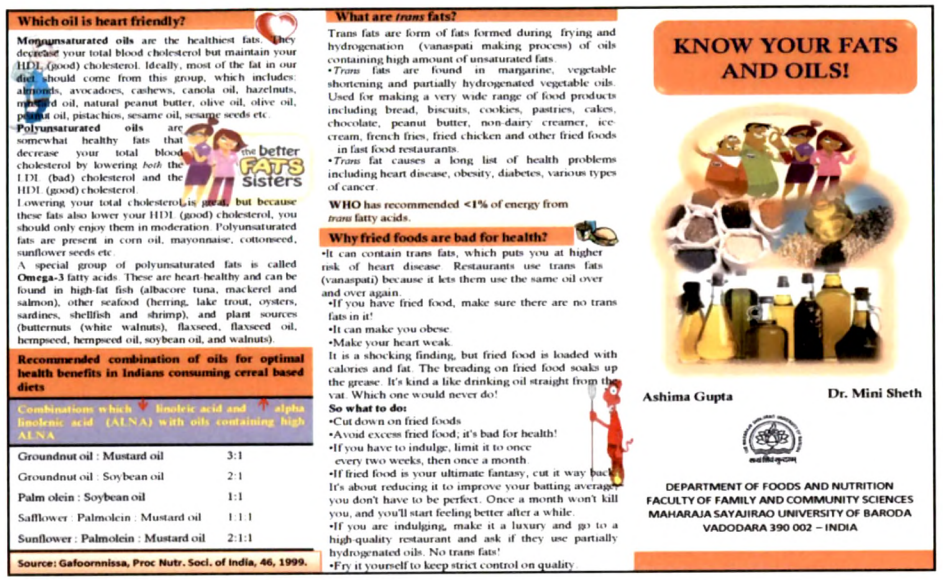
5.5.2: To develop IEC material on frying and problems during frying.

5.5.1: To develop IEC material on edible oil, types of oil and its composition.

"KNOW YOUR FATS AND OILS" IEC material was developed in two languages (Hindi and English) shown in Figure 5.5.1.

5.5.2: To develop IEC material on frying and problems during frying.

Figure 5.5.2 shows education material on frying, safety of fried foods, common problems envisaged during frying and calorie content of common fried foods.



Which oil is heart friendly?

Monounsaturated oils are the healthiest fats. They decrease your total blood cholesterol but maintain your HDL (good) cholesterol. Ideally, most of the fat in our diet should come from this group, which includes: almonds, avocadoes, cashews, canola oil, hazelnuts, mustard oil, natural peanut butter, olive oil, olive oil, peanut oil, pistachios, sesame oil, sesame seeds etc.

Polyunsaturated oils are somewhat healthy fats that decrease your total blood cholesterol by lowering *both* the LDL (bad) cholesterol and the HDL (good) cholesterol.

Lowering your total cholesterol is great but because these fats also lower your HDL (good) cholesterol, you should only enjoy them in moderation. Polyunsaturated fats are present in corn oil, mayonnaise, cottonseed, sunflower seeds etc.

A special group of polyunsaturated fats is called **Omega-3** fatty acids. These are heart-healthy and can be found in high-fat fish (albacore tuna, mackerel and salmon), other seafood (herring, lake trout, oysters, sardines, shellfish and shrimp), and plant sources (butternuts (white walnuts), flaxseed, flaxseed oil, hempseed, hempseed oil, soybean oil, and walnuts).

Recommended combination of oils for optimal health benefits in Indians consuming cereal based diets

Combinations which ↓ linoleic acid and ↑ alpha linolenic acid (ALNA) with oils containing high ALNA

Groundnut oil : Mustard oil	3:1
Groundnut oil : Soybean oil	2:1
Palm olein : Soybean oil	1:1
Safflower : Palmolein : Mustard oil	1:1:1
Sunflower : Palmolein : Mustard oil	2:1:1

Source: Gafoornissa, Proc Nutr. Socl. of India, 46, 1999.

What are *trans* fats?

Trans fats are form of fats formed during frying and hydrogenation (vanaspati making process) of oils containing high amount of unsaturated fats.

•*Trans* fats are found in margarine, vegetable shortening and partially hydrogenated vegetable oils. Used for making a very wide range of food products including bread, biscuits, cookies, pastries, cakes, chocolate, peanut butter, non-dairy creamer, ice-cream, french fries, fried chicken and other fried foods in fast food restaurants.

•*Trans* fat causes a long list of health problems including heart disease, obesity, diabetes, various types of cancer.

WHO has recommended **<1%** of energy from *trans* fatty acids.

Why fried foods are bad for health?

•It can contain trans fats, which puts you at higher risk of heart disease. Restaurants use trans fats (vanaspati) because it lets them use the same oil over and over again.

•If you have fried food, make sure there are no trans fats in it!

•It can make you obese.

•Make your heart weak.

It is a shocking finding, but fried food is loaded with calories and fat. The breading on fried food soaks up the grease. It's kind a like drinking oil straight from the vat. Which one would never do!

So what to do:

•Cut down on fried foods

•Avoid excess fried food; it's bad for health!

•If you have to indulge, limit it to once every two weeks, then once a month.

•If fried food is your ultimate fantasy, cut it way back. It's about reducing it to improve your batting average; you don't have to be perfect. Once a month won't kill you, and you'll start feeling better after a while.

•If you are indulging, make it a luxury and go to a high-quality restaurant and ask if they use partially hydrogenated oils. No trans fats!

•Fry it yourself to keep strict control on quality

KNOW YOUR FATS AND OILS!

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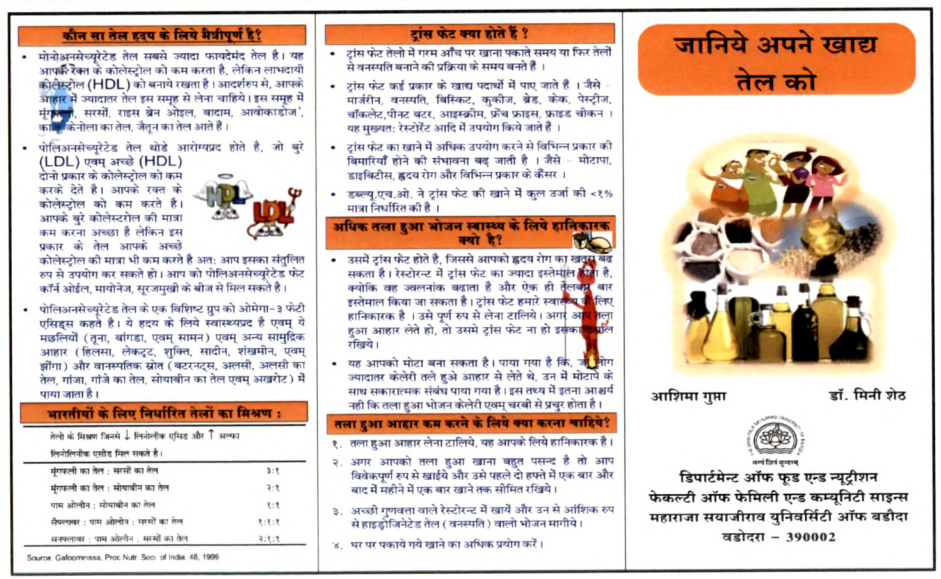


कौन सा तेल हृदय के लिये मैत्रीपूर्ण है?

• मोनोअनसेच्यूरेटेड तेल सबसे ज्यादा फायदेमंद तेल है। यह आपके रक्त के कोलेस्ट्रोल को कम करता है, लेकिन लाभदायी कोलेस्ट्रोल (HDL) को बनाये रखता है। आदर्शरुप से, आपके आहार में ज्यादातर तेल इस समूह से लेना चाहिये। इस समूह में मूंगफली, सरसों, राइस ब्रेन ऑइल, बादाम, आवोकाडोज', कनोला तेल, जैतून का तेल आते हैं।

• पोलिअनसेच्यूरेटेड तेल थोडे आरोग्यप्रद होते है, जो बुरे (LDL) एवम् अच्छे (HDL) दोनो प्रकार के कोलेस्ट्रोल को कम करके देते है। आपके रक्त के कोलेस्ट्रोल को कम करते है। आपके बुरे कोलेस्टरोल की मात्रा कम करना अच्छा है लेकिन इस प्रकार के तेल आपके अच्छे कोलेस्ट्रोल की मात्रा भी कम करते है अत: आप इसका संतुलित रुप से उपयोग कर सकते हो। आप को पोलिअनसेच्यूरेटेड फेट कॉर्न ऑईल, मायोनेज, सूरजमुखी के बीज से मिल सकते है।

• पोलिअनसेच्यूरेटेड तेल के एक विशिष्ट ग्रुप को ओमेगा-३ फेटी एसिड्स कहते है। ये हृदय के लिये स्वास्थ्यप्रद है एवम् ये मछलियों (तूना, बांगडा, एवम् सामन) एवम् अन्य सामुद्रिक आहार (हिलसा, लेकट्रट, शुक्ति, सार्डीन, शंखमीन, एवम् झींगा) और वानस्पतिक स्रोत (बटरनट्स, अलसी, अलसी का तेल, गांजा, गांजे का तेल, सोयाबीन का तेल एवम् अखरोट) में पाया जाता है।

भारतीयों के लिए निर्धारित तेलों का मिश्रण :

तेलो के मिश्रण जिनमे ↓ लिनोलीक एसिड और ↑ अल्फा लिनोलिनिक एसीड मिल सकते है।

मूंगफली का तेल : सरसों का तेल	३:१
मूंगफली का तेल : सोयाबीन का तेल	२:१
पाम ओलीन : सोयाबीन का तेल	१:१
पैल्मोलेइन : पाम ओलीन : सरसों का तेल	१:१:१
सनफ्लावर : पाम ओलीन : सरसों का तेल	२:१:१

Source: Gafoornissa, Proc Nutr. Soc. of India, 46, 1999

ट्रांस फेट क्या होते हैं ?

• ट्रांस फेट तेलो मे गरम आँच पर खाना पकाते समय या फिर तेलों से वनस्पति बनाने की प्रक्रिया के समय बनते है ।

• ट्रांस फेट कई प्रकार के खाद्य पदार्थों में पाए जाते है । जैसे - मार्जरीन, वनस्पति, बिस्किट, कुकीज, ब्रेड, केक, पेस्ट्रीज, चॉकलेट,पीनट बटर, आइस्क्रीम, फ्रेंच फ्राइस, फ्राइड चीकन । यह मुख्यत: रेस्टोरेंट आदि मे उपयोग किये जाते है ।

• ट्रांस फेट का खाने में अधिक उपयोग करने से विभिन्न प्रकार की बिमारियाँ होने की संभावना बढ़ जाती है । जैसे - मोटापा, डाइबिटीस, हृदय रोग और विभिन्न प्रकार के कैंसर ।

• डब्ल्यू.एच.ओ. ने ट्रांस फेट की खाने में कुल उर्जा की <१% मात्रा निर्धारित की है ।

अधिक तला हुआ भोजन स्वास्थ्य के लिये हानिकारक क्यो है?

• उसमें ट्रांस फेट होते है, जिससे आपको हृदय रोग का खतरा बढ़ सकता है। रेस्टोरन्ट में ट्रांस फेट का ज्यादा इस्तेमाल होता है, क्योंकि वह ज्वलनांक बढ़ाता है और ऐक ही तेलका बार इस्तेमाल किया जा सकता है। ट्रांस फेट हमारे स्वास्थ्य के लिए हानिकारक है । उसे पूर्ण रुप से लेना टालिये। अगर आप तला हुआ आहार लेते हो, तो उसमे ट्रांस फेट ना हो इसका ध्यान रखिये।

• यह आपको मोटा बना सकता है। पाया गया है कि, जो लोग ज्यादातर कोलेरी तले हुअे आहार से लेते थे, उन में मोटापे के साथ सकारात्मक संबंध पाया गया है। इस तथ्य में इतना आश्चर्य नही कि तला हुआ भोजन कोलेरी एवम् चरबी से प्रचुर होता है ।

तला हुआ आहार कम करने के लिये क्या करना चाहिये?

१. तला हुआ आहार लेना टालिये, यह आपके लिये हानिकारक है ।

२. अगर आपको तला हुआ खाना बहुत पसन्द है तो आप विवेकपूर्ण रुप से खाईये और उसे पहले दो हफ्ते में एक बार और बाद में महीने में एक बार खाने तक सीमित रखिये ।

३. अच्छी गुणवत्ता वाले रेस्टोरन्ट में खायें और उन से आंशिक रुप से हाइड्रोजिनेटेड तेल (वनस्पति) वाली भोजन मांगीये ।

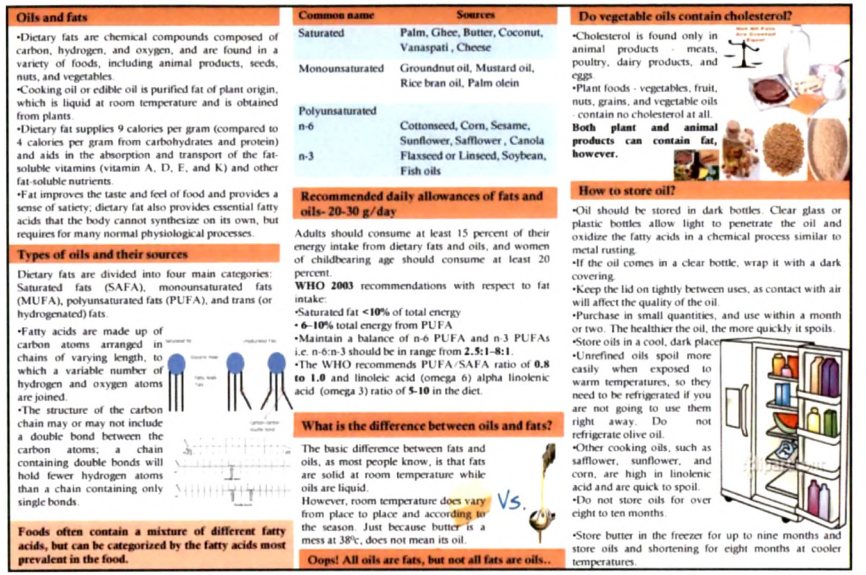
४. घर पर पकाये गये खाने का अधिक प्रयोग करें ।

जानिये अपने खाद्य तेल को

आशिमा गुप्ता

डॉ. मिनी शेठ

डिपार्टमेन्ट ऑफ फूड एन्ड न्यूट्रीशन
फेकल्टी ऑफ फेमिली एन्ड कम्यूनिटी साइन्स
महाराजा सयाजीराव युनिवर्सिटी ऑफ बडीदा
वडोदरा – 390002



Oils and fats

•Dietary fats are chemical compounds composed of carbon, hydrogen, and oxygen, and are found in a variety of foods, including animal products, seeds, nuts, and vegetables.

•Cooking oil or edible oil is purified fat of plant origin, which is liquid at room temperature and is obtained from plants.

•Dietary fat supplies 9 calories per gram (compared to 4 calories per gram from carbohydrates and protein) and aids in the absorption and transport of the fat-soluble vitamins (vitamin A, D, E, and K) and other fat-soluble nutrients.

•Fat improves the taste and feel of food and provides a sense of satiety; dietary fat also provides essential fatty acids that the body cannot synthesize on its own, but requires for many normal physiological processes.

Types of oils and their sources

Dietary fats are divided into four main categories: Saturated fats (SAFA), monounsaturated fats (MUFA), polyunsaturated fats (PUFA), and trans (or hydrogenated) fats.

•Fatty acids are made up of carbon atoms arranged in chains of varying length, to which a variable number of hydrogen and oxygen atoms are joined.

•The structure of the carbon chain may or may not include a double bond between the carbon atoms; a chain containing double bonds will hold fewer hydrogen atoms than a chain containing only single bonds.

Foods often contain a mixture of different fatty acids, but can be categorized by the fatty acids most prevalent in the food.

Common name	Sources
Saturated	Palm, Ghee, Butter, Coconut, Vanaspati , Cheese
Monounsaturated	Groundnut oil, Mustard oil, Rice bran oil, Palm olein
Polyunsaturated	
n-6	Cottonseed, Corn, Sesame, Sunflower, Safflower , Canola
n-3	Flaxseed or Linseed, Soybean, Fish oils

Recommended daily allowances of fats and oils- 20-30 g/day

Adults should consume at least 15 percent of their energy intake from dietary fats and oils, and women of childbearing age should consume at least 20 percent.

WHO 2003 recommendations with respect to fat intake:

•Saturated fat **<10%** of total energy

• **6-10%** total energy from PUFA

•Maintain a balance of n-6 PUFA and n-3 PUFAs i.e. n-6:n-3 should be in range from **2.5:1-8:1**.

•The WHO recommends PUFA/SAFA ratio of **0.8 to 1.0** and linoleic acid (omega 6) alpha linolenic acid (omega 3) ratio of **5-10** in the diet.

What is the difference between oils and fats?

The basic difference between fats and oils, as most people know, is that fats are solid at room temperature while oils are liquid.

However, room temperature does vary from place to place and according to the season. Just because butter is a mess at 38°c, does not mean its oil.

Oops! All oils are fats, but not all fats are oils..

Do vegetable oils contain cholesterol?

•Cholesterol is found only in animal products – meats, poultry, dairy products, and eggs.

•Plant foods - vegetables, fruit, nuts, grains, and vegetable oils - contain no cholesterol at all.

Both plant and animal products can contain fat, however.

How to store oil?

•Oil should be stored in dark bottles. Clear glass or plastic bottles allow light to penetrate the oil and oxidize the fatty acids in a chemical process similar to metal rusting.

•If the oil comes in a clear bottle, wrap it with a dark covering.

•Keep the lid on tightly between uses, as contact with air will affect the quality of the oil.

•Purchase in small quantities, and use within a month or two. The healthier the oil, the more quickly it spoils.

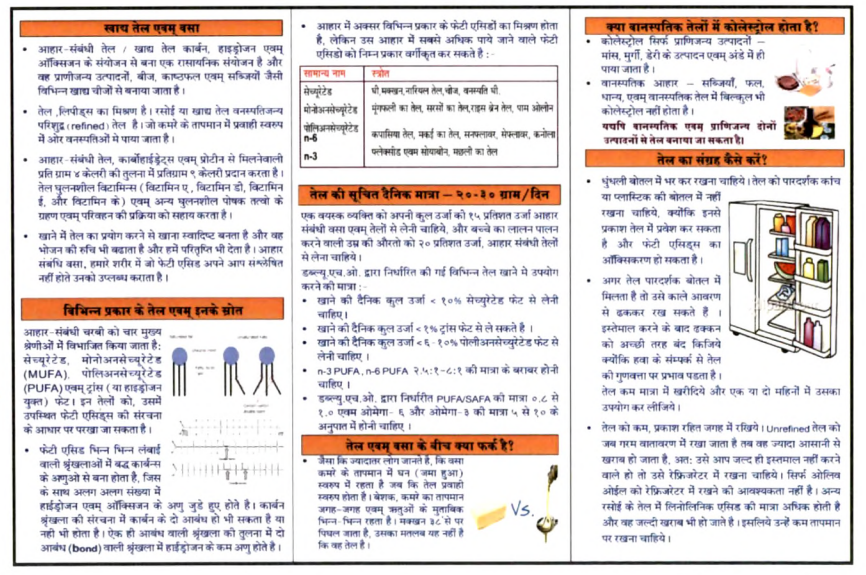
•Store oils in a cool, dark place.

•Unrefined oils spoil more easily when exposed to warm temperatures, so they need to be refrigerated if you are not going to use them right away. Do not refrigerate olive oil.

•Other cooking oils, such as safflower, sunflower, and corn, are high in linolenic acid and are quick to spoil.

•Do not store oils for over eight to ten months.

•Store butter in the freezer for up to nine months and store oils and shortening for eight months at cooler temperatures.



स्वाद्य तेल एवम् वसा

• आहार-संबंधी तेल / खाद्य तेल कार्बन, हाइड्रोजन एवम् ऑक्सिजन के संयोजन से बना एक रासायनिक संयोजन है और वह प्राणीजन्य उत्पादनों, बीज, काष्टफल एवम् सब्जियों जैसी विभिन्न खाद्य चीजो से बनाया जाता है ।

• तेल ,लिपीड्स का मिश्रण है। रसोई या खाद्य तेल वनस्पतिजन्य परिशुद्ध (refined) तेल है । जो कमरे के तापमान में प्रवाही स्वरुप में और वनस्पतीओ मे पाया जाता है ।

• आहार -संबंधी तेल, कार्बोहाईड्रेट्स एवम् प्रोटीन से मिलनेवाली प्रति ग्राम ४ केलरी की तुलना में प्रतिग्राम ९ केलरी प्रदान करता है। तेल घुलनशील विटामिन्स (विटामिन ए , विटामिन डी, विटामिन ई, और विटामिन के) एवम् अन्य घुलनशील पोषक तत्वो के ग्रहण एवम् परिवहन की प्रक्रिया को सहाय करता है ।

• खाने में तेल का प्रयोग करने से खाना स्वादिष्ट बनता है और वह भोजन की रुचि भी बढ़ाता है और हमे परितृप्ति भी देता है । आहार संबंधि वसा, हमारे शरीर में जो फेटी एसिड अपने आप सश्लेषित नहीं होते उनको उपलब्ध कराता है ।

विभिन्न प्रकार के तेल एवम् इनके स्रोत

आहार-संबंधी चरबी को चार मुख्य श्रेणीओं में विभाजित किया जाता है: सेच्यूरेटेड, मोनो अनसेच्यूरेटेड (MUFA), पोलिअनसेच्यूरेटेड (PUFA) एवम् ट्रांस (या हाइड्रोजन युक्त) फेट। इन तेलों को, उसमें उपस्थित फेटी एसिड्स की संरचना के आधार पर परखा जा सकता है ।

• फेटी एसिड भिन्न भिन्न लंबाई वाली श्रृंखलाओं में बद्ध कार्बन्स के अणुओ से बना होता है, जिस के साथ अलग अलग संख्या में हाईड्रोजन एवम् ऑक्सिजन के अणु जुडे हुए होते है। कार्बन श्रृंखला की संरचना में कार्बन के दो आबंध हो भी सकता है या नही भी होता है। ऐक ही आबंध वाली श्रृंखला की तुलना मे दो आबंध (bond) वाली श्रृंखला मे हाईड्रोजन के कम अणु होते है।

• आहार में अक्सर विभिन्न प्रकार के फेटी एसिडों का मिश्रण होता है, लेकिन उस आहार में सबसे अधिक पाये जाने वाले फेटी एसिडो को निम्न प्रकार वर्गीकृत कर सकते है :-

स्वास्थ्य नाम	स्रोत
सेच्यूरेटेड	घी, मक्खन, नारियल तेल, चीज, वनस्पति घी.
मोनोअनसेच्यूरेटेड	मूंगफली का तेल, सरसों का तेल,राइस ब्रेन तेल, पाम ओलेन
पोलिअनसेच्यूरेटेड n-6	कार्थिमा तेल, मक्की का तेल, सनफ्लावर, सेफ्लावर, कनोला
n-3	फ्लेक्सीड एवम सोयाबीन, माहली का तेल

तेल की सूचित दैनिक मात्रा – २०-३० ग्राम/दिन

एक वयस्क व्यक्ति को अपनी कुल उर्जा की १५ प्रतिशत उर्जा आहार संबंधी वसा एवम् तेलों से लेनी चाहिये, और बच्चे का लालन पालन करने वाली उम्र की औरतो को २० प्रतिशत उर्जा, आहार संबंधी तेलों से लेना चाहिये ।

डब्ल्यू.एच.ओ. द्वारा निर्धारित की गई विभिन्न तेल खाने मे उपयोग करने की मात्रा :-

• खाने की दैनिक कुल उर्जा < १०% सेच्यूरेटेड फेट से लेनी चाहिए ।

• खाने की दैनिक कुल उर्जा < १% ट्रांस फेट से ले सकते है ।

• खाने की दैनिक कुल उर्जा < ६- १०% पोलीअनसेच्यूरेटेड फेट से लेनी चाहिए ।

• n-3 PUFA, n-6 PUFA २:१-८:१ की मात्रा के बराबर होनी चाहिए ।

• डब्ल्यू.एच.ओ. द्वारा निर्धारित PUFA/SAFA की मात्रा ०.८ से १.० एवम ओमेगा- ६ और ओमेगा-३ की मात्रा ५ से १० के अनुपात में होनी चाहिए ।

तेल एवम् वसा के बीच क्या फर्क है?

जैसा कि ज्यादातर लोग जानते है, कि वसा कमरे के तापमान में घन (जमा हुआ) स्वरुप में रहता है जब कि तेल प्रवाही स्वरुप होता है। बेशक, कमरे का तापमान जगह-जगह एवम् ऋतुओं के मुताबिक भिन्न-भिन्न रहता है। सत्तावन ३८° से पर पिघल जाता है, उसका मतलब यह नहीं है कि वह तेल है।

क्या वानस्पतिक तेलों में कोलेस्ट्रोल होता है?

• कोलेस्ट्रोल सिर्फ प्राणिजन्य उत्पादनों – मांस, मुर्गी, डेरी के उत्पादन एवम् अंडे में ही पाया जाता है ।

• वानस्पतिक आहार – सब्जियाँ, फल, धान्य, एवम् वानस्पतिक तेल में बिल्कुल भी कोलेस्ट्रोल नहीं होता है ।

यद्यपि वानस्पतिक एवम् प्राणिजन्य दोनों उत्पादनों से तेल बनाया जा सकता है।

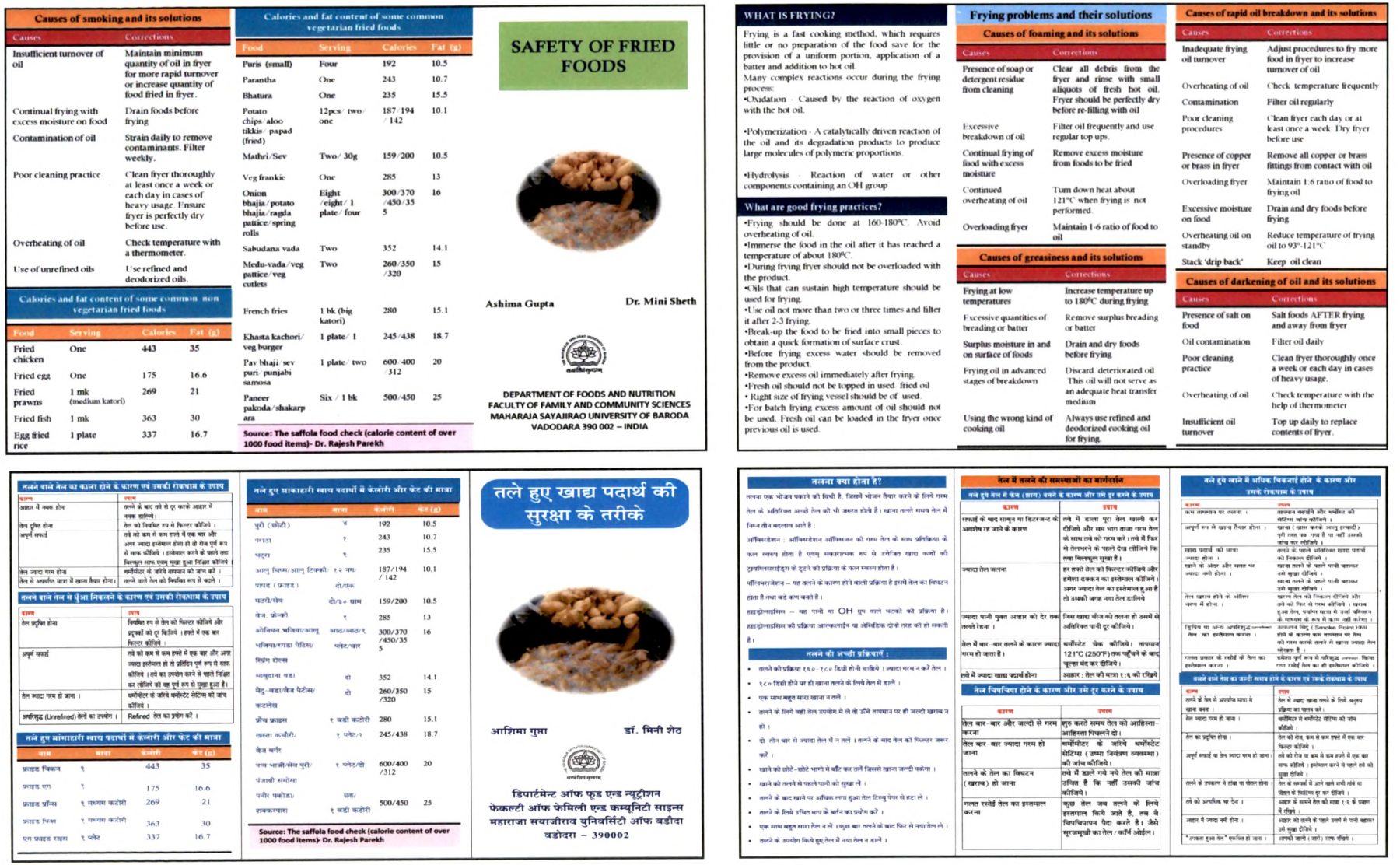
तेल का संग्रह कैसे करें?

• धुंधली बोतल में भर कर रखना चाहिये। तेल को पारदर्शक कांच या प्लास्टिक की बोतल में नहीं रखना चाहिये, क्योंकि इनसे प्रकाश तेल में प्रवेश कर सकता है और फेटी एसिड्स का ऑक्सिकरण हो सकता है ।

• अगर तेल पारदर्शक बोतल में मिलता है तो उसे काले आवरण से ढककर रख सकते हैं । इस्तेमाल करने के बाद ढक्कन को अच्छी तरह बंद किजिये क्योंकि हवा के संपर्क से तेल की गुणवत्ता पर प्रभाव पडता है । तेल कम मात्रा में खरीदिये और एक या दो महिनों में उसका उपयोग कर लीजिये ।

• तेल को कम, प्रकाश रहित जगह में रखिये । Unrefined तेल को जब गरम वातावरण में रखा जाता है तब वह ज्यादा आसानी से खराब हो जाता है, अत: उसे आप जल्द ही इस्तमाल नहीं करने वाले हो तो उसे रेफ्रिजरेटर में रखना चाहिये। सिर्फ ओलिव ओईल को रेफ्रिजरेटर में रखने की आवश्यकता नहीं है। अन्य रसोई के तेल में लिनोलिनिक एसिड की मात्रा अधिक होती है और वह जल्दी खराब भी हो जाते है। इसलिये उन्हें कम तापमान पर रखना चाहिये ।

Figure 5.5.1: Brochure on oils and fats in English and Hindi



Causes of smoking and its solutions

Causes	Corrections
Insufficient turnover of oil	Maintain minimum quantity of oil in fryer for more rapid turnover or increase quantity of food fried in fryer.
Continual frying with excess moisture on food	Drain foods before frying
Contamination of oil	Strain daily to remove contaminants. Filter weekly.
Poor cleaning practice	Clean fryer thoroughly at least once a week or each day in cases of heavy usage. Ensure fryer is perfectly dry before use.
Overheating of oil	Check temperature with a thermometer.
Use of unrefined oils	Use refined and deodorized oils.

Calories and fat content of some common non vegetarian fried foods

Food	Serving	Calories	Fat (g)
Fried chicken	One	443	35
Fried egg	One	175	16.6
Fried prawns	1 mk (medium katori)	269	21
Fried fish	1 mk	363	30
Egg fried rice	1 plate	337	16.7

Calories and fat content of some common vegetarian fried foods

Food	Serving	Calories	Fat (g)
Puris (small)	Four	192	10.5
Parantha	One	243	10.7
Bhatura	One	235	15.5
Potato chips/ aloo tikkis/ papad (fried)	12pcs/ two/ one	187/194 / 142	10.1
Mathri/Sev	Two/ 30g	159/200	10.5
Veg frankie	One	285	13
Onion bhajia/potato bhajia/ragda pattice/spring rolls	Eight /eight/ 1 plate/ four	300/370 /450/35 5	16
Sabudana vada	Two	352	14.1
Medu-vada/veg pattice/veg cutlets	Two	260/350 /320	15
French fries	1 bk (big katori)	280	15.1
Khasta kachori/ veg burger	1 plate/ 1	245/438	18.7
Pav bhaji/ sev puri/ punjabi samosa	1 plate/ two	600/400 /312	20
Paneer pakoda/shakarpara	Six / 1 bk	500/450	25

Source: The saffola food check (calorie content of over 1000 food items)- Dr. Rajesh Parekh

SAFETY OF FRIED FOODS

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WHAT IS FRYING?

Frying is a fast cooking method, which requires little or no preparation of the food save for the provision of a uniform portion, application of a batter and addition to hot oil.
Many complex reactions occur during the frying process:
•Oxidation - Caused by the reaction of oxygen with the hot oil.

•Polymerization - A catalytically driven reaction of the oil and its degradation products to produce large molecules of polymeric proportions.

•Hydrolysis - Reaction of water or other components containing an OH group

What are good frying practices?

•Frying should be done at 160-180°C. Avoid overheating of oil.
•Immerse the food in the oil after it has reached a temperature of about 180°C.
•During frying fryer should not be overloaded with the product.
•Oils that can sustain high temperature should be used for frying.
•Use oil not more than two or three times and filter it after 2-3 frying.
•Break-up the food to be fried into small pieces to obtain a quick formation of surface crust.
•Before frying excess water should be removed from the product.
•Remove excess oil immediately after frying.
•Fresh oil should not be topped in used fried oil
• Right size of frying vessel should be of used.
•For batch frying excess amount of oil should not be used. Fresh oil can be loaded in the fryer once previous oil is used.

Frying problems and their solutions

Causes of foaming and its solutions

Causes	Corrections
Presence of soap or detergent residue from cleaning	Clear all debris from the fryer and rinse with small aliquots of fresh hot oil. Fryer should be perfectly dry before re-filling with oil
Excessive breakdown of oil	Filter oil frequently and use regular top ups.
Continual frying of food with excess moisture	Remove excess moisture from foods to be fried
Continued overheating of oil	Turn down heat about 121°C when frying is not performed.
Overloading fryer	Maintain 1-6 ratio of food to oil

Causes of greasiness and its solutions

Causes	Corrections
Frying at low temperatures	Increase temperature up to 180°C during frying
Excessive quantities of breading or batter	Remove surplus breading or batter
Surplus moisture in and on surface of foods	Drain and dry foods before frying
Frying oil in advanced stages of breakdown	Discard deteriorated oil This oil will not serve as an adequate heat transfer medium
Using the wrong kind of cooking oil	Always use refined and deodorized cooking oil for frying.

Causes of rapid oil breakdown and its solutions

Causes	Corrections
Inadequate frying oil turnover	Adjust procedures to fry more food in fryer to increase turnover of oil
Overheating of oil	Check temperature frequently
Contamination	Filter oil regularly
Poor cleaning procedures	Clean fryer each day or at least once a week. Dry fryer before use
Presence of copper or brass in fryer	Remove all copper or brass fittings from contact with oil
Overloading fryer	Maintain 1:6 ratio of food to frying oil
Excessive moisture on food	Drain and dry foods before frying
Overheating oil on standby	Reduce temperature of frying oil to 93°-121°C
Stack 'drip back'	Keep oil clean

Causes of darkening of oil and its solutions

Causes	Corrections
Presence of salt on food	Salt foods AFTER frying and away from fryer
Oil contamination	Filter oil daily
Poor cleaning practice	Clean fryer thoroughly once a week or each day in cases of heavy usage.
Overheating of oil	Check temperature with the help of thermometer
Insufficient oil turnover	Top up daily to replace contents of fryer.

तलने वाले तेल का काला होने के कारण एवं उसकी रोकथाम के उपाय

कारण	उपाय
आहार में नमक होना	तलने के बाद तले से दूर करके आहार में नमक डालिये।
तेल दूषित होना	तेल को नियमित रूप से फिल्टर कीजिये।
अपूर्ण सफाई	तले को कम से कम हफ्ते में एक बार और अगर ज्यादा इस्तेमाल होता हो तो रोज पूर्ण रूप से साफ कीजिये। इस्तेमाल करने के पहले तवा बिल्कुल साफ, एकदम सूखा हुआ निश्चित कीजिये।
तेल ज्यादा गरम होना	थर्मोमीटर के जरिये तापमान की जांच करें।
तेल से अपवर्तित धारा में खाना तैयार होना।	तलने वाले तेल को नियमित रूप से बदले।

तलने वाले तेल से धुआं निकलने के कारण एवं उसकी रोकथाम के उपाय

कारण	उपाय
तेल दूषित होना	नियमित रूप से तेल को फिल्टर कीजिये और प्रदूषकों को दूर किजिये। हफ्ते में एक बार फिल्टर कीजिये।
अपूर्ण सफाई	तले को कम से कम हफ्ते में एक बार और अगर ज्यादा इस्तेमाल हो तो प्रतिदिन पूर्ण रूप से साफ कीजिये। तले का उपयोग करने से पहले निश्चित कर लीजिये की वह पूर्ण रूप से सूखा हुआ है।
तेल ज्यादा गरम हो जाना।	थर्मोमीटर के जरिये थर्मोमीटर स्टेटिग्स को जांच कीजिये।
अपरिशुद्ध (Unrefined) तेलों का उपयोग।	Refined तेल का प्रयोग करें।

तले हुए मांसाहारी खाद्य पदार्थों में कैलोरी और फैट की मात्रा

नाम	मात्रा	कैलोरी	फैट (g)
फ्राइड चिकन	१	443	35
फ्राइड एग	१	175	16.6
फ्राइड प्रॉन्स	१ मध्यम कटोरी	269	21
फ्राइड फिश	१ मध्यम कटोरी	363	30
एग फ्राइड राइस	१ प्लेट	337	16.7

तले हुए शाकाहारी खाद्य पदार्थों में कैलोरी और फैट की मात्रा

नाम	मात्रा	कैलोरी	फैट (g)
पूरी (छोटी)	४	192	10.5
पराठा	१	243	10.7
भटूरा	१	235	15.5
आलू चिप्स/आलू टिक्की/ २ नग/ पापड़ (फ्राइड)	दो/एक	187/194 / 142	10.1
मठरी/सेव	दो/३० ग्राम	159/200	10.5
वेज. फ्रेन्की	१	285	13
ओनियन भजिया/आलू भजिया/रगडा पेटिस/ सिंग्रेग रोल्स	आठ/आठ/१ प्लेट/चार	300/370 /450/35 5	16
सागुदाना वडा	दो	352	14.1
मेदु-वडा/वेज पेटीस/ कटलेस	दो	260/350 /320	15
फ्रेंच फ्राइस	१ बड़ी कटोरी	280	15.1
खस्ता कचौरी/ वेज बर्गर	१ प्लेट/१	245/438	18.7
पाव भाजी/सेव पूरी/ पंजाबी समोसा	१ प्लेट/दो	600/400 /312	20
पनीर पकोड़ा/ शक्करपारा	छह/ १ बड़ी कटोरी	500/450	25

Source: The saffola food check (calorie content of over 1000 food items)- Dr. Rajesh Parekh

तले हुए खाद्य पदार्थ की सुरक्षा के तरीके

आशिमा गुप्ता डॉ. मिनी शेठ

डिपार्टमेन्ट ऑफ फूड एन्ड न्यूट्रीशन
फेकल्टी ऑफ फेमिली एन्ड कम्यूनिटी साइन्स
महाराजा सयाजीराव युनिवर्सिटी ऑफ बडौदा
वडोदरा – 390002

तलना क्या होता है?

तलना एक भोजन पकाने की विधी है, जिसमें भोजन तैयार करने के लिये गरम तेल के अतिरिक्त अन्यके तेल की भी जरूरत होती है। खाना तलते समय तेल में निम्न तीन बदलाव आते है :

ऑक्सिडेशन - ऑक्सिडेशन की वजह तेल के साथ प्रतिक्रिया के फल स्वरुप होता है एवम् स्वकारात्मक रूप से उत्तेजित खाद्य कणों की ट्रायग्लिसराईड्स के टूटने की प्रक्रिया के फल स्वरुप होता है।

पॉलिमराजेशन – यह तलने के कारण होने वाली प्रक्रिया है इसमें तेल का स्निघटन होता है तथा बदें कण बनते है।

हाइड्रोलाइसिस – यह पानी या OH ग्रुप वाले घटकों की प्रक्रिया है। हाइड्रोलाइसिस की प्रक्रिया आल्कलाईन या ओसिडिक दोनों तरह की हो सकती है।

तलने की अच्छी प्रक्रियाएँ :

- तलने की प्रक्रिया १५०-१८० डिग्री होनी चाहिये। ज्यादा गरम न करें तेल।
- १८० डिग्री होने पर ही खाना तलने के लिये तेल में डालें।
- एक साथ बहुत सारा खाना न तलें।
- तलने के लिये सही तेल उपयोग में ले तो ऊँचे तापमान पर ही जल्दी खराब न हो।
- दो-तीन बार से ज्यादा तेल में न तलें। तलने के बाद तेल को फिल्टर जरूर करें।
- खाने को छोटे-छोटे भागों में बाँट कर तलें जिससे खाना जल्दी पकेगा।
- खाने को तलने से पहले पानी को सुखा लें।
- तलने के बाद खाने पर अधिक लगा हुआ तेल टिश्यू पेपर से हटा लें।
- तलने के लिये उचित माप के बर्तन का प्रयोग करें।
- एक साथ बहुत सारा तेल न लें। कुछ बार तलने के बाद फिर से नया तेल लें।
- तलने के उपयोग किये हुए तेल में नया तेल न डालें।

तेल में तलने की समस्याओं का मार्गदर्शन

तले हुये तेल में फेन (झाग) बनने के कारण और उसे दूर करने के उपाय

कारण	उपाय
सब्जियों के बाद सामान्य या फिटरकल्ट के अवशेष रह जाने के कारण	तले में डालने पूरा तेल खाली कर दीजिये और खब भाग ताजा गरम तेल के साथ तले को गरम करें। तले में फिर से तेलभरने के पहले देख लीजिये कि तवा बिल्कुल सूखा है।
ज्यादा तेल जलना	हर हफ्ते तेल को फिल्टर कीजिये और हमेशा ढक्कन का इस्तेमाल कीजिये। अगर ज्यादा तेल का इस्तेमाल हुआ है तो उसकी जगह नया तेल डालिये
ज्यादा पानी युक्त आहार को देर तक तलते रहना।	जिस खाद्य चीज को तलना हो उसमें से अतिरिक्त पानी दूर कीजिये।
तेल में बार-बार तलने के कारण ज्यादा गरम हो जाता है।	थर्मोस्टेट चेक कीजिये। तापमान 121°C (250°F) तक पहुँचने के बाद चूल्हा बंद कर दीजिये।
तले में ज्यादा खाद्य पदार्थ होना	आहार : तेल की मात्रा १:६ की रखिये

तेल चिपचिपा होने के कारण और उसे दूर करने के उपाय

कारण	उपाय
तेल बार-बार और जल्दी से गरम करना	शुरु करते समय तेल को आहिस्ता-आहिस्ता पिघलने दो।
तेल बार-बार ज्यादा गरम हो जाना	थर्मोमीटर के जरिये थर्मोस्टेट सेटिंग्स (उष्मा नियंत्रण व्यवस्था) की जांच कीजिये।
तलने के तेल का विघटन (खराब) हो जाना	तले में डाले गये नये तेल की मात्रा उचित है कि नहीं उसकी जांच कीजिये।
गलत रसोई तेल का इस्तमाल करना	कुछ तेल जब तलने के लिये इस्तमाल किये जाते है, तब वे विघटिपापन पैदा करते है। जैसे सूरजमुखी का तेल / कॉर्न ओईल।

तले हुये खाने में अधिक चिकनाई होने के कारण और उसके रोकथाम के उपाय

कारण	उपाय
कम तापमान पर तलना।	तापमान बढ़ाईये और थर्मोस्ट की जाँच कीजिये।
अपूर्ण रूप से खाना तैयार होना।	खाना (खास करके आलू डम्पलीं) पूरी तरह पक गया है या नहीं उसकी जांच कर लीजिये।
खाद्य पदार्थ की मात्रा ज्यादा होना।	तलने के पहले अतिरिक्त खाद्य पदार्थ को निकाल दीजिये।
खाने के अंदर और सतह पर ज्यादा नमी होना।	खाना तलने के पहले पानी चारकर अच्छी सुखा दीजिये। खाना तलने के पहले पानी चारकर उसे सुखा दीजिये।
तेल खराब होने के अतिरिक्त कारण में होना।	खराब तेल को निकाल दीजिये और तले को फिर से साफ कीजिये। खराब हुआ तेल, पर्याप्त खाद्य से उसे चिपचिपा के मात्रायुक्त के रूप में काम नहीं करेगा।
हिड्रिग या अन्य अपरिशुद्ध तेल का इस्तेमाल करना।	तापमान बिंदु (Smoke Point) कम होने के कारण काम तापमान पर तेल को गरम करके तलने से खाना ज्यादा तेल सोखता है।
गलत प्रकार के रसोई के तेल का इस्तेमाल करना।	इसीलए पूर्ण रूप से परिशुद्ध किस्म रसोई तेल का ही इस्तेमाल कीजिये।

तलने वाले तेल का जल्दी खराब होने के कारण एवं उसके रोकथाम के उपाय

कारण	उपाय
तलने के तेल से अपवर्तित मात्रा में खाना बनना।	तेल से ज्यादा खाद्य तलने के लिये अनुचय प्रक्रिया का पालन करें।
तेल ज्यादा गरम हो जाना।	थर्मोमीटर से थर्मोस्टेट सेटिंग्स की जांच कीजिये।
तेल का प्रदूषित होना।	तेल को रोज, कम से कम हफ्ते में एक बार फिल्टर कीजिये।
अपूर्ण सफाई या तेल ज्यादा गरम हो जाना।	तले को रोज या कम से कम हफ्ते में एक बार साफ कीजिये। इस्तेमाल करने से पहले तले को सुखा दीजिये।
तलने के उपकरण में हवा या पीतल होना।	तेल के खराब में आने वाले सभी तले या पीतल के सिंथेटिक पुर्जा को दूर कीजिये।
तले को अपवर्तित पर देना।	आहार में डालने तेल की मात्रा १:६ के प्रमाण में रखिये।
आहार में ज्यादा नमी होना।	आहार को तलने से पहले उसमें से पानी चारकर उसे सुखा दीजिये।
* टपका हुआ तेल* एकत्रित हो जाना।	अल्पमात्रा (ज्यादा) तलन रखिये।

Figure 5.5.2: Brochure on safety of fried foods in English and Hindi