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OIL USAGE PRACTICES AMONG SMALL AND MEDIUM SIZED SNACK VENDORS IN SOUTH DELHI, INDIA

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ABSTRACT

The increasing burden of chronic disease have spurred multi-pronged strategic efforts at policy and advocacy levels to minimize trans fatty acid consumption in India. This study aimed to investigate cooking and oil usage practices and oil quality among 50 small and medium sized vendors in South Delhi, India. Information on vendor practices was collected through a survey and oil quality was analysed by gas chromatography. Soy bean oil (86%) was the most frequently reported frying medium used. Availability (34%) was the commonest reason cited for choice of oils followed by taste and health factors. The commonly sold deep fried snacks included *bread pakora* (n= 32), *samosa* (n= 30) and *alootikki* (n= 21). Cast iron utensils (*karahis*) were most commonly used by vendors for deep frying. 42/50 vendors reported intermittent and re- heating of oils; 20 vendors were reusing the leftover oil/ fat. Only 10% of vendors surveyed were aware of the term "trans fatty acid" and its possible health impacts. The fatty acid profile analysis showed high levels of saturated fats. Intervention strategies should target both oil production and import policies and promote awareness among food vendors for a beneficial impact on population health.

Keywords: Oil usage, vendors, fatty acid profile, deep frying

INTRODUCTION

Snacks- the foods eaten in between meals have become an integral part of diets due to changing dietary and lifestyle practices in all the countries, whether developed or developing (Fellow P, Hilmi M.2011). Often these snacks are deep- fried and are widely available at small and medium sized vendors. The quality of these snacks depends on the oil/ fat used for frying (FreirePCM, LoboLCB, FreitasGS, FerreiraTAPC, 2013). The consumption of these deep- fried snacks has increased the fat and total energy intake levels which play an important role in health and disease (Guallar- Castillon P, et. Al 2007). India accounts for 10% of the world's edible oil consumption. Excessive consumption of fats in diet elevates blood cholesterol, which is then responsible for atherosclerosis, leading to cardio- vascular diseases (CVDs) and other related disorders. CVDs are currently one of the largest contributors to chronic disease burden in India (Lim SS, et.al 2010). Improving dietary intakes is an important modifiable risk factor for cardiovascular diseases (Lim SS, et.al 2010).

The sources of trans fatty acids (TFA) in human diets include animal sources (e.g. dairy products and ruminant meats), but most are supplied by products containing industrially produced partially hydrogenated vegetable oils (PHVOs; e.g. margarines, shortenings worldwide, *vanaspati* in India). These partially hydrogenated vegetable oils are commonly used in households and by vendors in India especially for deep frying purposes or as shortening. Various metabolic and epidemiological studies have reported that consumption of trans fatty acids confers increased risk of coronary heart disease (CHD) due to changes in blood lipid levels and derangement in other physiological pathways contributing to the increased risk (Guallar- Castillon P , et. al 2012, Mozaffarian D, 2006, Kris- Etherton PM, 2010).

Apart from the hydrogenation of vegetable oils as one of the causes of TFA production, repeated and prolonged heating and reuse of the same oil has been seen to be associated with an increase in the trans fat content. Different geometrical and positional isomers are formed from fatty acids after thermal treatments (Martin CA , et al 2007, Grandgirard A, et al, 1989, Destaillats F & Angers P , 2002), although only temperatures above 180- 190^{0}C will result in production of TFA in fats and oils (Wolff RL, 1993). These temperatures are typically reached and sometimes surpassed during deep fat frying, which means that TFA, even though they are minor components, increase in frying oils (Sanibal EAA , et al 2004, Romero A, et al, 2000) and fried products (Romero A , et al , 2000, Sebedio JL, et al 1996). As deep frying is normally carried out at high temperatures (between 160^{0}C and 180^{0}C) and

in the presence of air and moisture, these frying oils and fats will undergo physical and chemical deterioration which will affect their frying performance and the storage stability of the fried products (Fauziah A, et al , 2000). Repeated heating and reuse of oils is also a common practice among food vendors in India and warrants further study given the increasing frequency of consumption of food cooked outside the home and lack of well- defined policies and stringent guidelines for cooking oils used by vendors.

Thus, the present study was conducted a) to investigate the cooking and oil usage practices among the small and medium sized vendors in South Delhi, India and b) to collect oil samples from vendors surveyed for fatty acid composition analysis.

MATERIALS AND METHODS

A community based cross- sectional study was conducted in a commercial area of South Delhi, India. The study sites were selected based on the list available from the Municipal Corporation of Delhi (MCD) of the South Delhi which included 15 wards. Ten CEB areas within each ward were selected using a random number generator process. Each CEB area was visited by the research team (consisting of Principal Investigator and Research Associate) and all the vendors selling ready- to- eat fried snacks in the areas were mapped. Small/medium (less than 50/50-100 employees) restaurants or roadside food vendors willing to divulge details about the food cooking methods and provide oil samples were included in the study. Migratory vendors were excluded from the study. A total of 50 small and medium sized vendors were surveyed.

The study included vendor survey along with the sampling of oils used for preparation of snacks. Thus, the survey was carried out in two phases: in 2011 and first quarter of 2012.. This was done to ensure parallel processing of samples for fat extraction as they were collected during the survey. Written informed consent was obtained from all subjects prior to the initiation of the study.

VENDOR SURVEY

The questionnaire used for data collection was pilot tested on 20 vendors in South Delhi and Gurgaon before using it in the actual survey. The subjects for pilot testing were selected purposively. Informed consent was obtained from the vendors prior to administration of the questionnaire and they were assured of the confidentiality of their responses.The information elicited included that on shop ownership, number of employees, duration of having worked in the establishment, average daily earning. Product and oil usage and frying related questions included those on the commonly sold savoury deep fried snacks, type of oil. Fat being used for deep frying and shortening, reason for choice of oil/ fat, type of utensil used and heating and re-usage of the oils used for frying, criteria used for testing the temperature for frying etc.

OIL SAMPLING

Samples of the oil used for preparing snacks were also obtained from the vendors willing to provide it and were collected in the capped glass tubes. The oil samples were collected at three different time points of the workday whenever possible. The fatty acid composition of the collected oil samples was analysed using gas chromatography (GC).

METHOD FOR FATTY ACID PROFILE ANALYSIS

The method of Ichihara and Fukubayashi (Ichihara K, & Fukubayashi Y, 2010) was followed for preparation of esters from the oils. Briefly, 1.5 ml of methanol and 0.3 ml of the 8.0% hydrochloric acid (HCl) solution were added to a lipid sample placed in a screw-capped glass test tube (16.5 mm x 105 mm) dissolved in 0.2 ml of toluene. The tube was vortexed, and then incubated and heated at 100°C for 1 h- 1.5 h for rapid reaction. After cooling to room temperature, 1 ml of hexane and 1 ml of water were added for extraction of fatty acid methyl esters (FAMEs). The tube was vortexed, and then the hexane layer was evaporated and stored in a nitrogen purged glass insert. The inserts were stored at -20 degrees before proceeding with gas chromatographic analysis.

GAS CHROMATOGRAPHIC ANALYSIS OF FAMES

After preparation of the fatty acid methyl esters from these samples, samples were run (in triplicate) on a Nucon gas chromatograph equipped with an FID detector, edited using the software (AIMIL) and characterized for their fatty acid profile and trans fat content. 1 µl of each FAME was taken for GC analysis**.** The operating conditions were: temperature, ^{0} C: injector, 225; detector, 285; initial temp, 100; ramp, 3 ^{0} C/min; final temp, 240; hold 15 min. The split ratio was: 200:1.

Identification of individual fatty acids within the sample was done by comparison with a standard mix available from NuChek Prep Inc, USA. Individual fatty acids were also spiked with individual fatty acid standards (from NuChek Prep Inc, USA and Restek India) for confirmation of the peaks. The quantity of individual fatty acids was expressed as the percentage of each fatty acid in the complete chromatogram. Unidentified peaks were not included in the quantification summary.

STATISTICAL ANALYSIS

All data was entered and analyzed using Microsoft Excel. The descriptive statistics including frequencies and percentages was computed for the questionnaire data. The fatty acids assessed in oils were expressed as percentage of total fatty acids measured. Since the distribution of fatty acids in oils was not normal, median and interquartile range was computed.

RESULTS

VENDOR SURVEY

GENERAL CHARACTERISTICS

Majority (80%) of the respondents were owners of the shop. The mean number of employees in the establishments surveyed (n=47) was 4 (3 had ≥20 employees). The vendors (52%) had 50- 100 buyers on an

average day (Table 1). Oils/fats were mainly procured from local market. A little over third of the vendors were selling 1 or 2 freshly prepared fried snacks through their outlet. The median number of snacks being sold by these vendors was 3; it ranged from 1-10. Most commonly sold snacks as reported by vendors were *bread pakora* (68%) followed by *samosa* (62%), *golgappe* (38%), *alootikki* (36%), *kachori* (36%), *papdichaat* (30%) and *dahibhalla/ vada*, (32%). The other freshly prepared fried snacks sold were *paneer pakora, and raj kachori*. Of all commonly sold snacks, *samosa, kachori and papdi* were the products using shortening as declared by vendors; with 80% vendors using *vanaspati* as shortening in these snacks.

Table 1: Characteristics of participants/ outlets in vendor survey

Characteristic	Number (n)	Percentages (%)
Respondents		
Cook	5	10
Owner	40	80
Helper	5	10
Ownership of shop		
Rent	20	40
Owner	30	60
Mean number of employees in the shop	4	
Average daily earning		
<2000 INR	20	71.4
2000- 5000 INR	6	21.4
5000- 10000 INR	2	7.1
Number of clients/ day		
<20	2	4
25- 50	17	34
50- 100	26	52
>100	5	10
Commonly sold savoury snacks*		
Bread pakora	34	68
Samosa	31	62
Aloo tikka	18	36
Golgappe	19	38
Kachori	18	36
PapdiChaat	15	30
Dahibhalla	16	32
Vada	3	6

*One vendor was selling more than one snack

FATS /OILS USED IN FRYING AND SHORTENING

Soybean oil was the most commonly used frying medium (n= 43/ 50; 86%) followed by *vanaspati* (n=13; 26%).Thirty three vendors were using soybean oil exclusively for deep frying. Only one vendor each reported use of sunflower and palmolein for frying (Table 2). Ninety- two percent (n=46) vendors did not vary oil type used for frying based on season. More than half of the vendors were using Vanaspati as shortening in products. Other ingredients reported included oil (n= 9), soda (n= 6) and *suji*/ bread crumbs (n= 1) for making the products crisp (Table 2). Most of the vendors were also double frying the product to make the product crisp. Availability (34%) was the most common reason cited for choice of oils followed by taste (20%) and health (22%) and quality factors (20%). Other reasons reported included reasonable prices (8%), shelf- life and habit (4% each). Only 5 vendors (10%) were aware of the term trans fatty acid and/ or its health implications.

Table 2: Types of oils used by vendors (as declared by vendor)

	Number (n)	Percentages (%)
Type of oils/ fat used for frying		
Soybean	43	86
Vanaspati	13	26
Mustard oil	4	8
Groundnut oil	4	8
Sunflower oil	1	2
Palmolein oil	1	2
Mixed oil	2	4
Ingredient used for shortening		
Vanaspati	28	56
Oil	9	18
Soda	6	12
Nothing	8	16
Suji/ bread crumbs	1	2

Table 3: Practices related to deep frying amongst vendors

	Number (n)	Percentages (%)
Utensil used for frying		
Steel	7	14
Aluminium	4	8
Cast iron	43	86
Capacity of frying vessel		
5 liters	18	36
10 liters	11	22
15 liters	9	18
20 liters	7	14
>20 liters	5	10
How much oil is poured at one time		
2 L	22	44
5 L	15	30
10 L	9	18
15 L	4	8
Average consumption of oil		
Upto 5 L	19	38
6- 10 L	17	34
11- 15 L	7	14
16- 20 L	3	6
>20 L	4	8

Replenish the oil amount after first usage		
Yes	35	70
No	15	30
Till what point oil is heated		
Smoking point	13	26
Very hot	21	42
Moderately hot	15	30
Odour	1	2
Criteria for testing the temperature for frying		
Through experience	28	56
Sprinkle jeera	2	4
Sprinkle water	1	2
Sprinkle raw dough tid- bits	19	38
Duration of burner being on		
Periodic	42	84
Continuous	8	16
Left over oil processes		
Use it elsewhere	2	4
Re- use it the next day for frying	22	44
Throw it	18	36
Sell it	8	16

DEEP FRYING PRACTICES

The common usage practices followed among vendors related to frying medium are shown in Table 3. More than half of the 50 vendors (n=35) indulged in practice of replenishing the frying oil with fresh oil during the day. Of 35 vendors, majority of vendors (n=27) replenished the frying oil when oil amount was half of the initial amount used. The leftover oil/fat at end of the day was reused again by 22 (44%) vendors for frying the following day whereas majority of the vendors (n=26; 52%) reported that they were not using leftover oil for further cooking. They were either throwing it or selling it to others. Few vendors (n= 8; 16%) reported that the used oil was sold to other vendors, who reused the deteriorated oil for cooking and frying purposes (Table 3).

The practice of intermittent heating was reported by majority of the vendors (84%). Most of the vendors (n= 43; 86%) were using utensils made of cast iron for frying purposes and had no scientific method (n= 28; 56%) of checking the frying temperature (Table 3).

FATTY ACID PROFILE OF OILS USED BY VENDORS

Twenty-nine vendors provided oil samples. Rest of the vendors (42%; n= 21) refused to provide the oil samples. Of these, oils from 3 different points were available from 17 (16+ 1; one vendor provided more than one type of oil) vendors (n= 51 oils). The remaining (n= 12) gave samples either at one or two time- points. Rest of the vendors refused to give oil samples. In all, oil samples from 29 vendors were analysed for fatty acid profile expressed as % of total fatty acids.

There were 29 oils for which fresh samples were available from the vendor. Twenty of these oils were soybean, 8 *vanaspati* and one sunflower each as declared by the vendors (Table-4).

FATTY ACID PROFILE OF SOYBEAN OIL SAMPLED

Half of the total soybean oil samples had saturated fatty acid (SFA) content lower than 30% (median: 31%; range: 15-59%), median mono- unsaturated fatty acids (MUFA) and poly- unsaturated fatty acids (PUFA) content was 25% (range: 7- 42%) and 41.5% (range: 8- 64%) respectively. Trans fatty acid (TFA) content in four of the soybean oil samples was 1% or greater, with the highest being 2%.

Table 4: Fatty Acid Profile of Oils Sampled from Vendors (n= 29)

Oil Sample*	SFA	MUFA (cis)	MUFA (trans)	PUFA (cis)	PUFA (trans)	Total Trans (MUFA trans + PUFA trans)
Soybean 1	15.04	22.24	0.00	61.58	0.33	0.33
Soybean 2	16.67	23.94	0.00	57.80	0.98	0.98
Soybean 3	17.01	19.12	0.00	63.08	0.58	0.58
Soybean 4	20.22	22.29	0.00	53.12	1.80	1.80
Soybean 5	22.52	16.53	0.00	59.00	1.57	1.57
Soybean 6	25.46	10.06	0.00	62.48	2.00	2.00
Soybean 7	26.31	25.31	0.00	46.91	0.59	0.59
Soybean 8	27.95	7.07	0.54	64.08	0.36	0.90
Soybean 9	29.60	19.31	0.27	50.40	0.31	0.57
Soybean 10	30.31	32.19	0.00	36.28	0.94	0.94
Soybean 11	31.93	32.00	0.00	35.36	0.69	0.69
Soybean 12	36.20	7.77	0.44	54.92	0.38	0.82
Soybean 13	36.51	29.83	0.86	30.25	0.41	**1.27**
Soybean 14	47.04	41.46	0.00	10.81	0.19	0.19
Soybean 15	48.16	40.60	0.00	9.89	0.16	0.16
Soybean 16	49.67	42.15	0.00	8.16	0.00	0.00
Soybean 17	51.00	33.71	0.00	15.30	0.00	0.00
Soybean 18	54.90	31.15	0.00	13.22	0.00	0.00

Soybean 19	58.01	29.95	0.00	11.46	0.45	0.45
Soybean 20	59.66	25.24	0.00	14.58	0.29	0.29
Vanaspati 1	76.77	7.15	4.73	4	0.16	4.89
Vanaspati 2	61.0	28.58	0.00	4.5	1.37	1.37
Vanaspati 3	62.50	17.90	10.43	3	2.85	13.28
Vanaspati 4	69.19	11.74	13.02	5.53	0.34	13.36
Vanaspati 5	50.96	41.66	0.00	6.76	0.59	0.59
Vanaspati 6	59.53	30.66	0.00	7.58	0.17	0.17
Vanaspati 7	54.15	38.01	0.00	7.76	0.03	0.03
Vanaspati 8	47.04	41.47	0.00	10.64	0.00	0.00
Sunflower	11.67	20.3	0.00	65.2	0.80	0.80

*Type of oil sampled is as stated by the vendors

FATTY ACID PROFILE OF *VANASPATI* SAMPLED

The median SFA, MUFA and PUFA content of *vanaspati* samples was 60% (50- 83%), 30% (7- 42%) and 6.2% (3- 10%) respectively. Half of the eight *vanaspati* samples had trans fatty acid content of 1.5% or higher.

FATTY ACID PROFILE OF SUNFLOWER OIL SAMPLED

The SFA, MUFA, PUFA and TFA content of the single sampled sunflower oil was 11.7%, 20.3%, 65.2% and 0.8% of total fatty acids.

Our objective was also to examine the changes in trans fatty acid content of oils during heating process i.e. to analyze if there was an increase in fatty acid content with continuous/ repeated heating which is a common practice seen in snack retail outlets. In the oils (n= 16) that were collected from the vendors at different time points, we did not find any significant changes in the fatty acid profiles. Although there was some increase in the SFA content in some of the samples but no change in the TFA content of the oils was observed.

DISCUSSION

The purpose of the present study was to investigate the practices and perceptions of oil usage among the food vendors in South Delhi, India and analyse oil quality of samples obtained from these vendors.

The poly- unsaturated oils tend to show a greater deterioration when used as frying medium due to faster oxidation. Soybean oil was used as the frying medium by 86% of the vendors in the present study, which has been shown to be susceptible to peroxidation due to its high unsaturated fatty acid content (Joshi S, Joshi SR, 2013). Countries like France, Belgium and Chile have laid down a maximum limit of 2% of linolenic acid on oils/ fats to be used for frying (Goyal N, Sundaraj P, 2009; Nazni and Jaganathan., 2014). Thus, heating of oils/ fats with higher levels of unsaturated fatty acids is considered likely to result in formation of products that are harmful to health. The major determinant of oil choice was reported to be availability followed by cost. This suggests that an improvement in the quality of oil could be promoted by agricultural and import policy changesthus improving the quality of the oil available through the supply chain. This intervention could prove beneficial for population health at large.

In terms of oil quality, the oils procured from the vendors indicate usage of mixed oils with high saturated content. In the context of our study, this possibly indicates usage of alternatives of PHVOs that provide similar product quality without having significant trans fatty acid content, a phenomena that will need to be tackled through interventions that are cost- effective and do not transfer additional cost to the customer. It is known that palm oil combined with palm stearin and often blended with liquid oils makes an excellent fat blend for manufacturing shortenings. The quantity of palm oil in shortenings varies from 30- 40%. In many formulations, up to 80% of palm oil and fractions can be accommodated (http://www.soyatech.com/Palm_Oil_Facts.htm.2015).

These would have high saturated fat content, thus having implications for health as suggested from current evidence on impact of saturated fat content on cardiovascular disease risk.Thus, an assessment of the suitability of suggested substitutes for trans fat consumption e.g. palm oil, interesterified oil is important to prevent any compromise with the long term health of populations (Hayes KC, Pronczuk A ,**Error! Reference source not found.**10).

Intermittent heating was a common practice by majority of the vendors surveyed in the study. Several studies have shown that continuously heated oil had better quality than oils used in a deep frying process subjected to constant temperature oscillations (Mehta U, Swinburn B, **Error! Reference source not found.**). The possibility of hydrolytic degradation is more when the oil is used for frying for a longer time as the food releases water. This results in loss of oxidative stability of oil due to the oxidation of lipids (Corsini MS, Jorge N, 2006). Continuous use of the once heated oil also result in the formation of unwanted by-products including trans fatty acids and cyclic polar compounds. Products present in heated oils have been shown to adversely impact biological parameters such as lipid profiles, oxidant status and atherosclerosis risk in the body (Xian TK, et al 2012). None of the vendors covered their frying utensil which would have further intensified the oxidation process due to light and air exposure (Corsini MS, Jorge N, 2006).

The replenishment of the used oil with the fresh oil was a common practice amongst the vendors surveyed. This is consistent with another study done in Brazil (Osawa CC, et al, 2010). This is to make up for the amount of oil absorbed by the fried food (Araujo JMA, 2008) without having to completely change the oil which would have both implications for costs and time. The higher the temperature, the better the frying process is a commonly held belief among the vendors.. About 70% of the vendors in the present study heated the frying oil to high

temperatures (either very hot or moderately hot) which is consistent with other studies reporting the frying temperatures to be between 129- 210°C (Freire PCM, et al, 2013 , Tavares M, et al, 2007). The recommended temperature range for frying foods is 160- 180C as higher temperatures lead to deterioration of the oil/ fat more rapidly. Regulation in many countries including Australia, Finland and Belgium, require that fats used in frying should not be heated above 180°C. The increase in frying temperature from 180- 215°C, as seen in the present study, causes an increase in the rates of thermal degradation and oxidation leading to the formation of trans fatty acids in the oil/ fat used (Bansal GJ , et al, 2009, Aladedunye FA & Przybylski R, 2009, Kala Al, 2012). The nature of the utensil used for deep frying can also influence the development of trans fatty acids in the oil/ fat used. Most of the vendors were using utensil made of cast iron for frying; which has been seen to cause highest increase in TFA content on heating (Kala Al, 2012).

LIMITATIONS

We included all the vendors in sampling frame who were willing to participate in the interview in order to get fair representation of the different type of snacks, otherwise only vendors who were using good quality oils would have been represented. At the time of survey, all the vendors agreed to provide oil samples but later refused; however we still included them in the final data analysis to enable a more comprehensive representation of different vendors.

CONCLUSION

The practices observed are of concern for the food safety authorities who could consider formulation of both education and enforcement strategies to enable implementation of healthy practices targeting the small and medium sized vendors. In addition, agricultural policy interventions to improve practices related to choice and usage of oils are also required. Our findings also indicate a need for research into determining the appropriateness of suggested substitutes for trans fat consumption e.g. palm oil, interesterified oil, particularly before they become insidiously embedded in the food supply similar to TFA resulting in intake levels (of saturated fat) that maycompromise long-term health.

ETHICS APPROVAL

Ethics approval was obtained from the Institutional Ethics Committee of Public Health Foundation of India and All India Institute of Medical Sciences. All procedures involving the human subjects were in accordance with the ethics standards of the committee.

REFERENCES

- Aladedunye FA, Przybylski R. Degradation and nutritional quality changes of oil during frying. Journal of the American Oil Chemists' Society. 2009; 86 (2): 149- 156.
- Araujo JMA.Quimica de alimentos: teoria e pratica. 4 ed., Vicosa UFV 2008.
- Bansal GJ, Zhou W, Tan TW, Neo FL, Lo HL. Analysis of trans fatty acids in deep frying oils by three different approaches. Food Chemistry. 2009; 116 (2): 535- 541.
- Corsini MS, Jorge N. Oxidative stability of vegetable oils used in frying of frozen cassava.Journal of Food Science and Technology (Campinas). 2006. 26 (1): 27- 32. Available from: http://dx.doi.org/10.1590/S0101-20612006000100005.
- Destaillats F, Angers P. Evidence for [1.5] sigmatropic rearrangements of CLA in heated oils. Lipids. 2002; 37: 435-8.
- Fauziah A, Razali I, Nor- Aini S. Frying performance of palm olein and high oleic sunflower oil during batch frying of potato crisps. Palm Oil Dev. 2000; 3: 1-7.
- Fellow P, Hilmi M. Selling street and snack foods.Diversification Booklet No. 18. Rural Infrastructure and Agro- Industries Division. Food and Agriculture Organization of the United Nations. Rome; 2011. http://www.fao.org/docrep/015/i2474e/i2474e00.pdf
- FreirePCM, LoboLCB, FreitasGS, FerreiraTAPC. Quality of deep frying oils and fats used in street- fairs in Goiania, Brazil.Journal of Food Science and Technology(Campinas). 2013; 33 (3): 569- 576.
- Goyal N, Sundaraj P. Are we unknowingly consuming trans fats and abused oils. Bulletin Nutrition Foundation of India. 2009.
- Grandgirard A, Piconneaux A, Sebedio JL, O'Keefe SF, Semon E, Le Quere JL. Occurrence of geometrical isomers of eicosapentanoic and docosahexaenoic acids in liver lipids of rats fed heated linseed oil. Lipids. 1989; 24: 799- 804.
- Guallar- Castillon P, Rodriguez- Artalejo, FornesNS, Banegas JR, Etxezarreta PA, Ardanaz E, Barricarte A, Chirlaque MD, Iraeta MD, Larranaga NL, Losada A, Mendez M, Martinez C, Quiros JR, Navarro C, Jakszyn P, Sanchez MJ, Tormo MJ, Gonzalez CA. Intake of fried foods is associated with obesity in the cohort of Spanish adults from the European Prospective Investigation into Cancer and Nutrition. Am JClinNutr. 2007; 86 (1): 198- 205.
- Guallar- Castillon P, Rodriguez- Artelejo F, Lopez-Garcia E, Leon- Munoz LM, Amiano P, Ardanaz E, Arriola L, Barricarte A, Buckland G, Chirlaque MD, Dorronsoro M, Huerta JM, Larranaga N, Marin P, Martinez C, Molina E, Navarro C, Quiros JR, Rodriguez L, Sanchez MJ, Gonzalez CA, Moreno-Iribas C. Consumption of fried foods amd risk of coronary heart disease: Spanish cohort of the European Prospective Investigation into Cancer and Nutrition study. BMJ. 2012; 344: e363; doi: 10.1136/bmj.e363.
- Hayes KC, Pronczuk A. Replacing transfat: the argument for palm oil with a cautionary note on

interesterification.J Am CollNutr. 2010; 29 (3):253S-284S.

- Ichihara K,Fukubayashi Y. Preparation of fatty acid methyl esters for gas- liquid chromatography. Journal of Lipid Research. 2010; 51 (3): 635- 640.
- Joshi S, Joshi SR. Cooking oils in health and disease. Chapter 140 [monograph online]. 2013 [Cited 2015 Apr 15]. Available from: www.apiindia.org/medicine_update_2013/chap140.pdf
- Kala Al, Joshi V, Gurudutt KN. Effect of heating oils and fats in containers of different materials on their trans fatty acid content. J Sci Food Agric. 2012; 92 (11): 2227- 33.
- Kris- Etherton PM.Trans fats and Coronary Heart Disease. Critical Reviews in Food Science and Nutrition. 2010; 50: 29- 30.
- Lim SS, VosT, Flaxman AD, Danaei G, Shibuya K, Adair- Rohani H, AlMazoroa MA, Amann M, Anderson HR, Andrews KG, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990- 2010: a systematic analysis for the Global Burden of Disease Study 2010.Lancet. 2012; 380:2224- 2260.
- Martin CA, Milinsk MC, Visentainer JV, Matsushita M, de- Souza NE. Trans fatty acid- forming processes in foods: a review. An Acad Bras Cienc. 2007; 79: 343- 50.
- Mehta U, Swinburn B. A review of factors affecting fat absorption in hot chips. Critical reviews in Food Science and Nutrition. 2001; 41 (2): 133- 154.
- Mozaffarian D, Katan MB, Ascheria A, Stampfer MJ, Willett WC.Trans fatty acids and cardiovascular disease.The New England Journal of Medicine. 2006; 354: 1601- 13.
- Nazni. P and Jaganathan. A Standardization and Proximate Analysis of Street Foods Sold In Salem District International Journal of Agricultural and Food Science , August, 2014; Vol.4, Issue (3): 94-99
- ISSN 2249-8516Osawa CC, Gonclaves IAG, Mendes FM. Evaluation of oils and fats frying commercial establishments of the city Campinas/ SP: Good practices are frying being served?; Alimentos e Nutricao, Araraquara. 2010; 21 (1):47- 55.
- Palm Oil Facts. Soytech Growing opportunities [Internet] 2015. Available from: http://www.soyatech.com/Palm_Oil_Facts.htm.
- Romero A, Cuesta C, Sanchez- Muniz FJ.Trans fatty acid production in deep fat frying of frozen foods with different oils and frying modalities.Nutr Res. 2000; 20: 599- 608.
- Sanibal EAA, Mancini- Filho J.Perfil de acidosgraxostrans de oleo e gordurahidrogenada de sojanoprocesso de fritura. Ci TecnolAlim. 2004; 24: 27- 31.
- Sebedio JL, Dobarganes MC, Marquez G, Wester I, Christie WW, Dobson G, Zwobada F, Chardigny JM, Mairot TH and Lahtinen R. Industrial production of crisps and prefried French fries using sunflower oils. Grassy y Aceites. 1996; 47: 5- 13.
- Tavares M, Gonzalez E, Passion MLS, Barsotti RCF, Kumagai EE, Caruso MSF, Aued- Pimentel S, Ruvieri V, Souza DM. Assessment of quality of oils and fats used for frying in trade in the metropolitan area of Santos, Sao Paulo. Journal of Adolfo Lutz Institute. 2007; 66 (1): 40- 44.
- Wolff RL. Further studies on artificial geometrical isomers of alpha- linolenic acid in edible acid-containing oils. J Am Oil Chem Soc. 1993; 70: 219-224.
- Xian TK, Omar NA, Ying LW, Hamzah A, Raj S, Jaarin K, Othman F, Hussan F. Reheated palm oil consumption and risk of atherosclerosis: evidence at ultrastructural level.Evid Based Complement Alternat Med. 2012; doi: 10.1155/2012/828170.