Nutritional Quality of Deep Fried Street-Vended Foods: A Public Health Concern

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Abstract: Many governments are determined to control the local trade of street-vended foods that are prepared and sold by street vendors. This growing practice is encouraged by the rise in urban populations, economical crisis and increase of unemployment among adults who tend to regard vending food as a reasonable way for income generation. Currently in the Middle East, there is a wide range of oriental recipes that are on sale at affordable prices and available to most socioeconomic levels. Deep fried food products come top of the selling list as they are cheap, culturally acceptable diet and palatable by Middle Eastern communities. Nevertheless, chemical and biological hazards are always associated with such type of foods. This article focusses on the chemical quality of vegetable oils that are used to prepare street food products. This has been demonstrated by a controlled laboratory trial, which mimicked the thermal abuse of vegetables oils by street food vendors. Samples of cooking oil (sunflower oil, corn oil, blend of cottonseed and sunflower oil and palm oil) revealed that there is a significant increase with heating time (7, 12 and 25 h) in saturated fatty acids. Levels of polyunsaturated fatty acids, on the other hand, tended to decrease with the heating time for these oils. Thermal oxidation induced chemical deterioration of cooking oils, in addition to some physical changes (darkening of the original colour, burnt smell, changes in viscosity and evolution of smoke during frying). Vulnerable group, particularly children and pregnant mothers, are at eminent risk of health complications through the cumulative effect of ingesting chemically abused cooking oils. Nutritional adequacy of programme aimed to improve the quality of street food products, behaviours and attitudes of the vendors should be introduced by governments, to re-assure food safety, health and well being.

Keywords: Street-Vended Foods, Intermittent Heating of Vegetable Oils, Unsaturated Fatty Acids, Chemical Deterioration, Thermal Oxidation

1 Introduction

Street-vended food can be defined as a fast meal sold by a vendor with a push cart, at a stall or kiosk (varies between municipal legislations across countries), in most occasions the customer would observe largely the preparation procedures.

The use of fat or oil for frying still remains one of the most popular methods for the preparation of foods. This is particularly true in many countries, where some deep fried food forms the staple food item in the diet and is also widely available at street level (e.g. 'fish and chips' and 'falafel' – a deep fried vegetable patties) (Bhat and Waghray, 2000; Blair, 1999; da Silva and Pereira, 2008; FAO/WHO, 1988; Tewfik et al., 1998; Zeyadah et al., 1993).

Fat or oil used in frying acts as heat transfer medium and as important ingredient of the fried food. Deep frying process at high temperature (approximately 190°C ± 5°C) and in presence of air and moisture allows thermal oxidation and degradation of fat and oil (Addis, 1986; Augustin, et al., 1987; Chang, et al., 1978; Frankel, et al., 1984; Fritsch, 1981; Jacobsom, 1967; Stevenson et al., 1984). Whether the process was continuously or intermittently, significant change to the physicochemical properties of the oil are observed that warrants a public health concern. Degradation reactions may vary; auto-oxidation, thermal polymerisation, cyclisation and hydrolysis (Chang et al., 1978; Fritsch, 1981; Giani et al., 1985; Tewfik et al., 1998). The extent and exact nature of these reactions are affected by the characteristics of the fried food, the composition of the fat and frying conditions, the temperature, exposure to oxygen, heating period, frying capacity (kg food/h), continuous or repeatedly frying, mode of heat transfer, metal in contact with oil, cleanliness of the fryer, turnover rate and initial quality of the oil (Stevenson et al., 1984; Tewfik et al., 1998; Zeyadah et al., 1993). Volatile and non-volatile compounds are the end products of the degradation reactions (Augustin, et al., 1987; Chen and Tappel, 1993; Fritsch, 1981). Although most of the volatiles are lost during the frying process, the non-volatile decompositional products remained. The latter are produced primarily by thermal oxidation and polymerisation of unsaturated fatty acids (Chang et al., 1978; Fritsch et al., 1981; Tewfik et al., 1998). These compounds are of public health concern because they accumulate in the frying oil where they promote further degradation and are absorbed by the fried food and enter the diet. Highly oxidised oils may also produce polyaromatic hydrocarbons that are thought to have a carcinogenic effect (FAO/WHO, 1980; Halliwell, 1994; Jayakumari et al., 1992; Tewfik et al., 1998). Thermal degradation of frying oils is therefore known to result in the accumulation of decomposition products which not only affect the quality of the fried food but is also the nutritional composition. The nutritional consequences of ingesting deteriorated oils are well documented and include a variety of symptoms ranging from an allergy of the digestive tract, growth retardation, to other biochemical lesions (Frankel et al., 1984). As the street vendors in many countries are known to provide a significant proportion of the fried food to wide range of population including vulnerable group, the main aim of this study was to monitor the chemical changes to the fatty acid profiles in the vegetable oils (sunflower oil, corn oil, blend of cottonseed and sunflower oil and palm oil) that are considered good indices in assessing the degree of thermal oxidation (Sebedio et al., 1988).

2 Materials and Methods

Owing to the wide variety of street-vended foods and modes of preparation, it was decided to just focus on deep fried practice. This has enabled us to study the vegetable oils (i.e. the frying medium) and associated factors that may enhance its chemical deterioration. Therefore a controlled laboratory trial was designed to mimic the frying practice of vegetable oils and to assess the potential modes for improvements. Twelve kilogram of different vegetable oils that are known to be commonly used for frying in Middle East region (sunflower oil, corn oil, blend of cottonseed and sunflower oil and palm oil) were brought to the chemical laboratory to carry out a controlled laboratory trial. Ten kilogram of each of the four oil samples was heated in an uncovered stainless steel frying pan to 190°C ± 5°C. The time required to heat the oil was between 20 and 25 min, after which, the temperature of the oil was maintained at 190°C ± 5°C for an hour. The oil was then allowed to cool to room temperature (45 min), after which it was reheated to the same temperature and maintained for a further hour. This cycle of intermittent heating was repeated five times a day, exposing each type of oil to a total of 5 h of intermittent heating per day. This employed procedure was to simulate the thermal abuse of vegetable oils.

Two kilogram sample was removed from each of the four frying pans after a total of 7, 15 and 25 h of intermittent heating at 190°C ± 5°C. Neither the fresh oil was added nor was the oil filtered during heating. Samples were in air tight containers stored in cool dark place, until their derivatisation to fatty acid methyl esters (FAMEs) (IUPAC, 1979) prior their injection on to gas chromatography (GC). The profiles of the FAMEs were determined by GC connected to a flame ionisation detector (FID).

The separation of fatty acid methyl esters of vegetable oils is by using GC-FID on a 30 m × 0.32 ID Econo-cap capillary column. Stationary phase was polyethylene glycol ester film having thickness of 0.25 μm. Carrier gas was helium and the flow rate was 50 ml/min. The oven temperature was programmed from 65 to 185°C at 8°C per min. Toluene was added as 'internal standard' in concentration of 0.1% in 10 ml heptane, and the computer was programmed to print out the peak height of each fatty acids methyl esters in the injected mixtures.

Table 1 Percentage of fatty acid methyl esters per total detected in different types of vegetable oils, which were thermally treated up to 25 h of intermittent heading at 190°C ± 5°C

	Percentage (%) of C16/ total fatty acids	Percentage (%) of C18/ total fatty acids	Percentage (%) of C18:1/ total fatty acids	Percentage (%) of C18:2/ total fatty acids	Percentage (%) of C18:3/ total fatty acids
At zero time					
Sunflower oil	6.2	3.79	43.37	46.64	Not detected
Corn oil	10.52	2.07	26.02	59.67	1.72
Cotton and sunflower oil	14.15	3.66	20.76	55.50	5.92
Palm oil	44.49	4.75	40.01	10.39	Not detected
At 7 hours					
Sunflower oil	6.39	3.88	47.31	42.40	
Corn oil	10.89	2.73	26.55	58.90	0.912
Cotton and sunflower oil	14.38	2.58	22.57	54.97	5.50
Palm oil	42.01	4.29	42.16	10.37	Not detected
At 15 hours					
Sunflower oil	6.32	4.54	49.28	39.84	
Corn oil	10.73	2.69	27.03	58.66	0.88
Cotton and sunflower oil	16.22	4.05	22.13	53.43	4.18
Palm oil	45.73	4.49	39.04	9.636	Not detected
At 25 hours					
Sunflower oil	6.63	4.30	50.24	38.55	Not detected
Corn oil	11.43	2.90	28.10	56.75	0.81
Cotton and sunflower oil	15.52	4.14	22.82	53.44	4.07
Palm oil	44.30	4.22	33.71	7.310	Not detected

3 Results

Table 1 shows the percentage (%) of individual fatty acid in total analysed fatty acids (caprylic C8, capric C10, lauric C12, myristic C14, palmitic C16, stearic C18, oleic C18:1, linoleic C18:2 and linolenic C18:3).

4 Thermal Abuse of Vegetable Oils

4.1 Sunflower Oil

The GC chromatograms showed that the percentage of linoleic acid (C18:2) decreased from 46.64 to 38.55%, meanwhile the percentage of oleic acid (C18:1) was increased from 43.37 to 50.24% after 25 h of intermittent heating in the presence of air (190°C ± 5°C).

4.2 Corn Oil

The content of linolenic acid (C18:3) started to decline from 1.72 to 0.8%, meanwhile the percent of linoleic acid (C18:2) decreased from 59.67 to 56.75%. Subsequently, the percentage of oleic acid (C18:1) increased by 2.08% after 25 h of intermittent heating.

4.3 Blend of Cotton Seed and Sunflower Oil

The percentage of polyunsaturated fatty acids: linolenic (C18:3) and linoleic acids decreased from 5.92 to 4.07% and from 55.50 to 53.44%, respectively. However, an increase in the percentage of oleic acid (C18:1) from 20.76 to 22.82% was observed after 25 h of intermittent heating.

4.4 Palm Oil

Table 1 denotes the reduction of the percentage of diunsaturated fatty acid; linoleic acid (C18:2) from 10.39 to 7.31% as well as a reduction in the percentage of the monounsaturated oleic acid (C18:1) from 40.01 to 33.71%. On the other hand, a noticeable increase in the percentage of saturated myrisitc acid (C14:0) from 0.397 to 10.44%.

5 Discussion

This study analysed the chemical abuse of vegetable oils that are currently used to prepare street food offered to people inhabiting the Middle East region.

5.1 Chemical Deterioration of Thermally Abused Vegetable Oils

The effect of intermittent heating on the chemical quality and structure of different types of tested oils were revealed by the use of gas chromatography. GC gave an appropriate figure about the effect of thermal abuse on some selected fatty acids such as palmitic C16, stearic C18, oleic C18:1, linoleic C182 and linolenic acid C18:3. The separation of FAMEs of vegetables oils showed a significant drop in the contents of unsaturated fatty acids. This can be explained on the basis that these fatty acids underwent lipid peroxidation and the drop of their contents is due to the breakdown of fatty acid chain during thermal oxidation into small chains aldehydes, ketones, oxidation products and shorter fatty acid chains, according to Farmer's theory (Farmer et al., 1942).

Thermal oxidation also affected the degree of unsaturation of C18:1, C18:2 and C18:3 in vegetable oils and gave rise to several oxidation products such as lipid peroxide, free radicals and hydroperoxides as a results of various types of degradation (e.g. thermal, hydrolytic, oxidative, combined oxidative and hydrolytic degradation). These oxidation products may render vegetable oil unfit for human consumption and the prolonged ingestion of foods which have been fried in these chemically deteriorated oils may pose a public health risks to all consumers (including vulnerable groups) by an array of non-communicable diseases, e.g. elevated blood pressure, atherosclerosis, cardiovascular diseases and cancer (Blair, 1999; Chen and Tappel, 1993; FAO/WHO, 1988; Giani et al., 1985; Halliwell, 1994; Jayakumari et al., 1992; Tewfik et al., 1998).

Results using chemical parameters as markers for thermally oxidized and abuse oils indicate that the ideal choice for frying is palm oil. However, palm oil is far from the ideal choice from nutritional or public health point of view and as such corn oil is recommended for frying purposes (Tewfik et al., 1998). Although chemical parameters are important in pinpointing thermally oxidized and abuse oils, it is possible to assess the state of the oils based on visual parameters such as darkening of the original colour, burnt smell, changes in viscosity and evolution of smoke during frying. In most instances, the polyunsaturated oils lasted up to 15 h of intermittent heating while palm oil (saturated) lasted in excess of 25 h (Tewfik et al., 1998).

To further reduce these detrimental effects and prolong the useful life of frying oils, the right choice of frying oil is essential. In addition, other factors are also important, which include regular cleaning and maintenance of equipment and utilization of proper frying conditions are required. One commonly used method of maintaining oil quality is to add fresh oil periodically. Another procedure to control the rate and degree of oil breakdown involves filtering the oil on a daily or continuous basis. Food particles, if not removed by filtration, may develop undesirable flavours and odours and increase the rate of oil deterioration (Addis, 1986; Jacobsom, 1967; Tewfik et al., 1998).

5.2 Field Visit

In addition to the aforementioned laboratory results, the study team set out to find equally important findings emerged from field visit to selected districts in the Middle East region, which is of considerable interest on the need to extend an influence on the hygienic practice of street-vended foods, these findings can be summarised as following:

- Street-vended foods thrive as a necessary element of the daily life of children, filling a need for reasonably priced food close to their schools. This applies not only to children but also to many urban dwellers who use food street vendors. One must also point out that street food vending provides employment not only to those engaged in the actual selling, but often to their family and close network of people who prepare – purchase and transport the food items. A very close communal effort that provides much needed income and purpose to a substantial number of people (Martins, 2006).
- The contamination of all items of foods could be very easily prevented through proper hygienic education and minor changes to their mode of vending with some additional health knowledge that improves food-selling habits (Mukhola, 2000).
- All sanitary conditions of the street vendors' carts, moveable stalls equipment and clothes are a major health risks. These equipments are constructed at the least possible cost with no observation of even minimal sanitation standards. These represent health hazards to citizens that could be prevented by health education.
- Street vendors are operating under negative circumstances, according to health and hygienic viewpoint, however from nutrition point they are providing an outlet in the fight of the poor communities for an adequate diet. A tremendous scope for improvement is apparent.
- The majority of street-vended foods were of acceptable energy and nutritive values. The most popular type of food was falafel, liver, chips, fish and eggplant sandwiches that were high in fat contents. These sandwiches were found to be largely consumed by children on a daily basis, providing children with a high intake of fats that may exceed their recommended daily allowance.
- In general, street-vended foods were excellent sources of energy and complex carbohydrates which are a form of sustainable energy, thus providing the children with a very high portion of their needed calories. However, foods varied in iron and vitamin A contents, but by and large the popularity of the dishes although not dictated by nutritional factors were found to be adequate from a nutritional point of view (Blair, 1999).
- Chemical contamination of the food was very minimal with the exception of degradation products of vegetable oils, which could be alleviated if the frying oil is discarded after 3 h of intermittent heating (Tewfik et al., 1998). Overall, it was obvious that the cheapest oil brand was used which added to the decrease of food quality. Better choice could improve on nutritional and storage quality.

6 Way Forward

It was clear that street vendors' knowledge of food processing, chemical deterioration of frying medium and food contamination was minimal. The occupation of being street vendors is familial legacies, which move from one generation to the other with the same cart, stand, and so forth, as well as, the same ignorance and complete lack of knowledge on safe food manufacture, hygiene and sanitary practice. Their presence and practice ensures that a large population of children in poor communities obtains a reasonably balanced high-protein diet at affordable price nevertheless; frying oils might risk their health. The poor hygienic conditions and minimal sanitation practices undermine the value and importance of food sold by street vendors. These factors, we believe, could change and improve through united efforts of the governments, NGOs, and local community workers.

In some Latin American cities (Bhat and Waghray, 2000) street food vending accounts for 30% of all sales within the economy of the country. It did appear to give work directly or indirectly to well more than 1 million people generating a substantial volume of monetary transactions that stimulate the national economies of countries involved (Arámbulo et al., 1994; Bhat and Waghray, 2000). One of the most important findings of the Latin America study is the scientific approach that was carried out to establish the type of food most acceptable and most in demand to children. These food facts might act as good guiding point when deciding a method to improve the perspective of future of street vending (Escalante de Cruz, 2003).

It is suggested that the food inspectors could expand their roles and act as advisors, promoting a change of attitude in vendors by offering them practical suggestions to improve on any existing fault. International organisation should extend cooperation to a local level to develop projects for sanitary improvement of food vendors as well as designing fixed stands that would appeal to consumers and vendors. Also, they should introduce and organise health education and promotion programmes directed at street vendors to help them produce more nutritive and better quality food.

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