REVIEW ON THE IMPACT OF PEROXIDE VALUE FROM EDIBLE OIL: INDIAN PERSPECTIVE.

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ABSTRACT

Due to a hectic lifestyle, people nowadays are dependent on fast food as it is convenient and tasty too which consists of fried food items that are cooked in reused oil that are highly susceptible to oxidation of unsaturated fats. This leads to production of peroxides making the oil rancid. Peroxide value of oil is determined by using different methods to determine the rancidity of oil. According to research and several studies, the majority of oil samples from fast food centers were over degraded containing hazardous secondary oxidative products. The higher the peroxide value the greater the changes of rancidity whereas lower peroxide value suggests good quality of the oil. Repeated deep frying and reusing the same oil makes it rancid and the quality deterioration may contribute to the formation of oxidation products that are reactive and toxic, that can ultimately lead to health risks, like inflammation, weight gain, digestive disorders, degeneration of tissues in general. Adverse effects include infertility, cancer, Alzheimer's, DNA damage in the long run. The current review studied the effects of peroxide in edible oil from an Indian perspective.

Key words: Peroxide, rancidity, inflammation, cancer.

INTRODUCTION

Today more and more people are consuming fast food due to a hectic and chaotic lifestyle. Fast food includes fried items which are quick and easy to make but highly unhealthy, more so because of the amount of oil it consumes. Fried foods have desirable taste and unique color, and texture, due to which they are consumed and preferred on a large scale (Goswami et al., 2015). One of the most important factors influencing the health aspects of fast food like fried items is the oil they are fried in (Varma, A et al., 2017). Oil plays an important role in a frying process, hence it should be fresh and of good quality. Oil constitutes one of the main components of our balanced diet and also supplies a good amount of energy (Kumar et al., 2018). The quality of the oil depends on its physical properties that include color, appearance, solidification temperature, texture, etc. and chemical properties that include values or amount of peroxide, iodine, acid, saponification, etc. (Venkata et al., 2016).

RANCIDITY

The composition of edible oil primarily includes fatty acids. Edible oil is commonly used in frying and cooking, medicine, cosmetics etc.(Kumar et al., 2018). When the same oil is reused for the frying process, and the oil is heated at very high temperatures for a long time, it leads to deterioration in oil quality. Due to this, there is development of unpleasant odor or taste in the oil, and this effect is called rancidity. This oil can have harmful effects

on human health. The quality of oil can be determined by measuring its peroxide value by using different methods (Seth 2019).

PEROXIDE VALUE

The measure of degree of primary oxidation that takes place in oils and fats due to certain reactions that include hydroxyl group and oxygen molecule to produce hydro peroxides is known as the peroxide value of oil. Different methods are used to measure the peroxide value in samples of oil (Sarwar et al., 2016). The oil samples having the peroxide value more than 10meq/kg is considered to be rancid and has various health hazards that includes, Diabetes, Obesity, cardiovascular diseases, infertility, Alzheimer, etc. There can be adverse effects on human health due to consumption of fried food cooked in rancid oil. This review is an attempt to understand the different ways by which peroxide value in oil samples can be determined and the impact of peroxide on human health (Seth, 2019).

HEALTH HAZARDS

Repeated heating leads to increase in PV and deteriorates the quality of oil. Depending upon food items fried in such repeatedly heated oil for a long time could directly affect the antioxidant defense network in humans that leads to problems like hypertension, diabetes and vascular inflammation. Oxidation of lipids can lead to increased risk for developing chronic heart disease. When there is a disbalance or disturbance between anti oxidative protective systems in our body, it results in formation of free radicals that are strong oxidizing substances, due to which the human body gets exposed to a significant oxidative stress. This stress can cause damage to DNA, protein, carbohydrates and lipids and can lead to negative effects on intracellular signal transmission (Goswami et al., 2015). India is a multicultural country with several cuisines and fast food stalls are a common phenomenon seen in the country.

The present study is an attempt to review and collect the data pertaining to the

IMPACT OF PEROXIDE VALUE FROM EDIBLE OIL in India.

MATERIALS AND METHODS

For this review study, we carried out an extensive search of research articles databases available in Google Scholar, NCBI, PubMed (Medline), SCOPUS etc. to find studies that has the information on effects of peroxide value in human health. We also looked through various references of the paper that were discovered earlier and related review papers and publications.

DISCUSSION

As per Codex and FSSAI food safety standards (2018), the oil samples having peroxide value less than 10 meq/kg is safe for human consumption, but oil samples having peroxide value less than 4 meq/kg are considered to be fresh and healthy (Goswami et al., 2015).

Peroxide is known to have toxic effects on human health, if the value exceeds 10 meq/kg (Sarwar et al., 2016) and can cause problems like cardiovascular disorders, effects on endothelial functions, elevated blood pressure and cholesterol levels and formation of mutagens that leads to cancer (Goswami et al., 2015).

Although globally quite extensive research has been carried out to estimate the amount of peroxide in used cooking oil and its effects on human and animal health, very minimal research has been conducted regarding the same in India. The present

review paper is an attempt to review the research work done in India in the context of peroxide value and its effects and compile the literature for future use and experimentation.

Almost all the researchers have used the standard titration method proposed by American Oil chemists (1972) which involves the use of acetic acid and chloroform mixture along with potassium iodide and starch solution. This is mixed with the oil sample, and this sample is titrated against sodium thiosulphate to get the desired peroxide value.

Pardeshi (2020) carried out experiments in the city of Jalgaon to determine the peroxide value of edible cooking oil collected from local markets. The research reported PV values to be more than 5 meq/kg and the highest PV was of palmolein oil (6.8 meq/kg). The studies obtained similar results to the work done by Goswami et al., (2015) in Rajasthan, who also studied the impact of high PV on health and found that it can cause adverse health effects like cancer and heart issues among others. In the experiment performed by Goswami et al., (2015), fresh oil samples were purchased from the market of Rajasthan and were used for frying the potatoes (Table No.1). The potatoes were fried in oil samples at very high temperatures of 170 to 180 degree Celsius and the left out oil was used for frying about 5 times. According to the results, the amount of peroxide was found to be increasing due to constant exposure to heat in all types of oil. The high values of peroxide marks the rise in products of lipid peroxidation that majorly includes peroxide, which was produced at the time of frying. The PV was measured after fifth frying, and the highest value was found of soybean oil that is stated in the table below. This proves that repeated heating leads to increase in PV and deteriorates the quality of oil. Ingestion of food prepared in reused and heated oil for a long duration can cause several health problems that include diabetes, hypertension, etc. Pardeshi attributed one of the factors that aid in high PV is the high temperatures oil is heated at and also their packaging and storage.

Oil Samples	**Peroxide Value (meq/kg)**
Coconut Oil	6.89
Sunflower Oil	8.42
Groundnut Oil	5.00
Soybean Oil	**10.88**
Mustard Oil	6.50
Palm Oil	6.01

Table 1- Results of peroxide value obtained in the experiment performed by Goswami et al., (2015)

Similar experiments were performed by Sarwar et al., (2016), in which the order of oil samples according to its peroxide value was as follows; Vanaspati > buffalo ghee > mustard oil > Castrol oil > rice bran oil > sunflower oil > groundnut oil = olive = cow ghee > coconut oil. According to the studies it was found that the oil with PV less than 10 meq/kg were found to be fresh in terms of smell and flavor while the oil samples

with PV of 30-40 meq/kg were observed to have a rancid taste. Rancid oil is proven to be deleterious to the human body (Sarwar et al.,2016), as it forms free harmful radicals in the body that are responsible to increase the risk of cancer, damage the cells and have been associated with diabetes, Alzheimer and heart disease. Research also shows that peroxides accelerate aging, raise cholesterol level, obesity etc. (Falade et al., 2015).

Varma et al., (2017), determined the PV of repeatedly heated oil samples for 40 minutes, procured from the local market. As given in Table 2, PV of cow ghee is lowest.

Oil Samples	**PV after first frying (meq/kg)**	**PV after second frying (meq/kg)**	**PV after third frying (meq/kg)**
Rice bran oil	1.8	6.9	8.1
Safflower oil	2.2	9.1	**13.2**
Olive oil	2.5	8.1	**11.8**
Cow ghee	1.1	3.4	6.1

Table 2- Results of peroxide value obtained in the experiment performed by Varma et al., (2017).

Authors like Seth (2019), performed experiments, in order to determine the quality parameters of edible oils in India. Seth (2019) concluded that on heating, hydrolysis in oil takes place due to which the free fatty acid (FFA), diacylglycerols (DAG) and monoacylglycerols (MAG) levels increase in oils. FFA generation and its oxidized compound leads to rancid taste in oil and deteriorates its quality. The increase in FFA and SFA (saturated fatty acids) in the human body increases the total cholesterol levels and low density lipoprotein (LDL) and accelerates the risk of developing coronary heart disease. The samples of Vanaspati ghee, coconut oil, and palm kernel oil are rich in SFA and its increased hydrolysis due to heating can also lead to cancer, insulin sensitivity, obesity and other disorders. This study supports the work done by other authors.

By this study, it can be concluded that along with the peroxide present in oil samples that is determined by Varma et al., (2016), the values of FFA, SFA also matters in oil samples, and along with high PV, the high FFA, SFA in oil can also lead to various health hazards.

In contrast Kumar et al., (2018) performed studies on PV on the basis of storage. This study was also based on determination of peroxide value but not due to repeated frying of oil at high temperatures, but on the basis of storage. After 210 days, the density, specific gravity, pH and PV of oil samples were measured. And it was observed that sunflower oil had the lowest peroxide value (0.16) and mustard oil had the highest of (0.34). It means that along with the process of frying, the method of storage, packaging, etc. are also characterized as an important factor in maintaining the quality of oil which supports the work of other researchers (Goswami et al., 2015), (Seth 2019).

Rats used as a model organism to demonstrate the effects on health –

Several researchers like Venkata et al. (2016) and Shastry et al., (2016) carried out experiments on rats to understand the impact of consuming repeatedly heated

used cooking oil on human health. Rat is the ideal model organism for such studies as their physiology, anatomy and genetics are similar to humans and the obtained results can be used to understand the effects in humans.

Venkata et al., (2016), fed rats with high PV oil samples as shown in Table No. 3 and observed deleterious effects. He attempted to study the fat content in the food and found that cooking at high temperature can lead to mutagen formation which results in cancer that targets different sites in the body. Some of the health effects of consumption of repeatedly heated cooking oil included high blood pressure, risk of cardiovascular disease, endothelial dysfunction, impaired vaso relaxation responses, hypertension, LDL and atherosclerosis. While some of the more adverse effects included, colon polyps that were mostly adenomas, vacuolated swelling of cytoplasm of hepatocytes, dysplasia and hypertrophy of sinusoidal kupffer cells and significant mucosal abnormality as seen the study.

Groups of Rat	**Oil Sample**	**Peroxide value** (meq/kg)
1st Group	Control	-
2nd Group	Unheated Cooking Oil (UHCO)	**11**
3rd Group	Singly Heated Cooking Oil (SHCO)	**18**
4th Group	Repeatedly Heated Cooking Oil (RHCO)	**34**

Table 3- Results of peroxide value obtained in the experiment performed by Venkata et al., (2016)

Shastry et al., (2011), carried out similar studies however they treated rats to lower PV oil samples (Table No. 4). The treated rats exhibited high values for serum glutamate-pyruvate transaminase (SGPT), serum glutamate-oxaloacetate transaminase (SGOT), and alkaline phosphatase (ALP) As per the histological examinations done, the group of rats treated with reused palm oil showed that the cell was swollen with chronic inflammatory cell infiltration in liver, congested myocardial in heart, cells in the medullary region of kidney showed presence of vacuoles in cytoplasm and nucleus of germ cells in testis was observed. The group of rats treated with reused sunflower oil showed vein congestion that was mild and fine fatty vacuoles in liver, papillary muscle and few vacuoles in heart, cells in the medullary region of kidney showed vacuoles with occasional tubule containing eosinophilic materials and testis showed presence of few vacuoles. From these results we can conclude that the process of repeated frying leads to development of free radicals and other harmful agents in oil. The same results can be used as a reference to further study and carry out experiments on humans.

Groups of Rat	**Oil Sample**	**Peroxide value** (meq/kg)
1st Group	Control	-
2nd Group	Fresh Palm Oil	3.18
3rd Group	Reused Palm Oil	4.85
4th Group	Fresh Sunflower Oil	6.6
5th Group	Reused Sunflower Oil	**17.3**

Table 4- Results of peroxide value obtained in the experiment performed by Shastry et al., (2011).

Adam et al., in 2008 performed similar experiment on rats in the year 2008, and observed that the effect of repeatedly heated soy oil in rats (ovariectomized) were adverse as they showed highest LDL increase and high serum LDL levels that can cause progression of atherosclerosis As per their studies it can be concluded that heating of soy oil for multiple times can cause a rise in lipid peroxidation and LDL in an ovariectomized rat which stimulates a host menopause state with deficiency of estrogen. Overheating leads to the pathogenesis of atherosclerosis mainly in host menopause women. Serum thiobarbituric acid reactive substance (TBARS) % was higher. All groups showed an increase in total cholesterol (TC) but rats treated with five times heated oil showed higher levels comparatively.

However, the effects observed in rats that were treated with thermally oxidized palm oil for 20 minutes ((Falade et al., 2015) showed rise in plasma and liver MDA (Malon dialdehyde) residue of groups fed with TPO when compared with control. The MDA content in liver was higher than that of plasma it means that lipid peroxidation can take place in liver, as liver plays a role in detoxification and gets exposed to certain free radicals and other relative species that can lead to destruction of its membrane integrity which results in leakage of enzymes from liver and oxidation stress. The thermally oxidized palm oil diets increased plasma total cholesterol (T-CHOL) with the highest in 20 minutes TPO. An increased cholesterol level in the blood has been implicated in cardiovascular diseases in these results. It has also been observed that HDL cholesterol levels have been decreased and LDL cholesterol level has been increased in 20 minutes TPO (Falade et al., 2015).

Jaarin et al., (2011) demonstrated the risk of reheated vegetable oils on blood pressure in Sprague rats. 11 groups of rats were made from which the control was fed with 1 time heated oil and other groups were fed with 2 times, three times and so on respectively. It was found that less heated palm and soy oil had no deleterious effects on blood pressure but they increased the citric oxide concentration and decreased the responses to phenylephrine but the palm and soy oil that was exposed to heat multiple times showed a rise in BP, increased phenylephrine-induced contraction low level acetylcholine, sodium nitroprusside induced relaxation as compared to control. The reheating activity of cooking oils leads to generation of free radicals like hydroperoxide, PUFA, and aldehydes that may lead to pathogenesis of hypertension in rats.

Studies done by Deshmukh (2019) and Poornima et al., (2019) compared the dependence of people on fried/ fast food and the possible health problems. Deshmukh (2019) studied the effects of 4 months of heated palm oil and soy oil injected in rats and concluded that available increased consumption of fast food, there is a rising rate of obesity worldwide. Poornima et al., (2019) carried out a survey based study, to understand the effect of peroxides and antioxidants released due to repeated frying of oil, on human health. Consumption of deep fried snacks in reused oil, leads to rise in blood cholesterol levels, which can cause atherosclerosis that leads to cardiovascular diseases and other disorders. The effects of reheated oils were observed on rodents. It is observed that the process of reheating has a harmful impact on vascular function. Overheating of palm oil and soybean oil leads to blockage in endothelium subordinate and vaso relaxations. Similar results were found by Venkata et al., (2016) in his experiment. It has been noted that repeated ingestion of thermally oxidized palm oil, leads to release of peroxides due to which the functions of aorta have been modified in rodents. This can lead to expansion in vascular reactivity that can increase blood pressure (Poornima et al., 2019).

As per the current review research it can be concluded that along with peroxide, the values of free fatty acid (FFA) and saturated fatty acid (SFA) are also important, to examine the quality of oil. On the basis of results, the oils that exceed 10 meq/kg lead to problems like cardiovascular disorders, effects on endothelial functions, elevated blood pressure and cholesterol levels and formation of mutagens that leads to cancer. From the present review conducted in India it can be concluded that the peroxide value can be changed and quality of oil can deteriorate not only due to repeated frying, but also due to pattern of packaging and storage.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to Dr. Zarine Bhathena, Prrincipal of Bhavan's College, and Dr. Balkrishna Gore, Head of Zoology Department for their support for working on- A review on the impact of peroxide value from edible oil in humans: Indian perspective. We would like to thank Mr. Adnan Bhanwadia and Ms. Prachi Hatkar for helping us in this project. We would also like to express our gratitude to our parents and friends for their assistance and support in completing the work within the limited period.

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