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The content and dietary exposure of Malondialdehyde in industrial and traditional ice cream fats

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ABSTRACT

Lipid oxidation is an undesirable reaction that produces unwanted and harmful compounds, including malondialdehyde (MDA). Ice cream has a considerable amount of fat; therefore, it is sensitive to lipid oxidation. The primary purpose of this study was to determine the lipid oxidation level in traditional and pasteurized ice creams. The traditional ice cream and various brands of pasteurized ice cream samples were collected. The amount of MDA was measured by the TBARS method, and dietary exposure to MDA was calculated. MDA levels in the traditional samples were lower than in pasteurized ice creams, however, it was not significant ($p>0.05$). The level of lipid oxidation was different in brands A, B, and C. The highest and lowest levels of MDA were found in brand A and brand C, respectively. The value of estimated dietary intake was calculated as 4.251 µg/Kg. This study showed that the amount of MDA could be very different in branded samples. Furthermore, the dietary intake of MDA is considerable. Therefore, it is necessary to develop a standard regarding the permissible level of MDA in ice cream.

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1. Introduction

Oxidation is one of the most important reactions that produce undesirable compounds by affecting the components of food.

Fat is very susceptible to oxidation, and lipid oxidation is one of the most important causes of chemical spoilage of food that can occur in the storage, distribution, and preparation stages (1).

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Furthermore, the production of harmful compounds and reduction the nutritional value are other side effects of lipid oxidation (2, 3). Lipid peroxidation usually occurs on unsaturated fatty acids. Following this process, the color, taste, and smell of food also become unfavorable (4).

Ice cream is one of the most popular frozen desserts globally; it contains ingredients such as milk, sugar, non-fat solids, and water. The ice cream ingredients include 12% fat, 11% skim milk, 15% sugar, or other sweeteners. Ice cream has a high nutritional value. Ice cream is prepared in both industrial and traditional ways (5). Milk and dairy products are sensitive to oxidative reactions due to their significant fat content with high unsaturated fatty acids. Due to the oxidation of milk fat, undesirable compounds such as free radicals and active aldehydes are formed (6-8). Free radicals are active molecules and can react rapidly with biomolecules, including DNA, protein, and lipid in the body's biological system (9-11). Increasing production of free radicals causes cellular oxidative degradation of fatty acids with several double bonds present in the cell membrane structure and is known as lipid peroxidation. If this oxidative degradation begins and continues in a chain, MDA is also produced. Increasing levels of Malondialdehyde cause cell damage (12-14). MDA has been measured in several foods (dairy products, nuts and meat) by different methods like Thiobarbituric Acid Reactive Substances (TBARS) Test and UPLC-DAD and UPLC-FLD, according to the Papastergiadis et al. 2012 and Bertolin et al. 2019 studies (15, 16).

Ice cream is very important in terms of the content of harmful substances, including MDA, due to its high consumption by children and the general public (17, 18). Ice-creams are usually marketed in two kinds of traditional ice cream and pasteurized industrial ice cream. This study aimed to investigate the amount of lipid peroxidation in traditional and pasteurized ice creams supplied in Tehran markets.

2.Materials and Methods

2.1. Sample collection

Twenty-five samples from different brands (A, B, C) of pasteurized ice cream as well as traditional ice cream that is relatively common in supermarkets were purchased in this study. The samples were sent to the laboratory, and the experiments were performed on them immediately.

2.2. Determination of Malondialdehyde (MDA)

MDA in ice cream samples was determined using thiobarbituric acid (TBA) as described previously (19). Two TBA molecules react with one MDA molecule under acidic conditions, and the final form of MDA-TBA forms a pink/red chromogen that can be detected on a spectrophotometer at 532-535 nm. Briefly, the samples were transferred to a clean tube, then added to the trichloroacetic acid solution (2 ml of 20% TCA) and filtered after centrifugation (2500 rpm in 15 min), finally the precipitate was removed. Then, 1 ml of the solution was transferred to a clean tube and thiobarbituric acid (2 ml, 0.67%) was added, the mixture was placed in the boiling water for 15 min. The solution was allowed to cool and placed in a spectrophotometer and MDA at 532 wavelengths.

2.3. Dietary Exposure

The per capita consumption of ice cream is about 3.5 kg for each Iranian, and the daily ice cream consumption is about 9.5 g. The average weight of an adult is 70 kg. Estimated daily intake (EDI) was calculated using the following formula (20).

$EDI = \frac{Ci \times Cc}{BW}$(mg/kg bw/day)

Ci: for the mean concentration of MDA =0.031 mg/kg

Cc: the average daily consumption of ice cream per person=0.0095 (kg)

BW: the body weight (kg)

2.4. Statistical analysis

The data represent the mean ± standard deviation for samples. Different brands' mean values were compared using the ANOVA test followed by Tukey post-hoc test. P-value <0.05 was considered statistically significant. Statistical analyzes were performed by SPSS software.

3. Results

The results of the analysis are summarized in Table 1 for traditional and industrial pasteurized ice cream. The amount of MDA in traditional ice creams was less than in industrial pasteurized ice creams (Table 1), however but this difference was not significant (p>0.05).

Table 1. Lipid oxidant comparison of traditional and industrial ice cream. Data are presented as mean ± SD.

Kind of ice cream	Level of MDA (µM/ml)
Traditional ice cream	2.07±1.3
Industrial pasteurized ice cream	2.4±1.2

Fig. 1 shows the level of lipid peroxidation for different brands of pasteurized ice cream. Brand A had the highest MDA, and the lowest MDA content was measured in brand C. The p-value between brands C with A was 0.01, brand C with B was 0.05, brand A with B was 0.035, and brand A with C was 0.045.

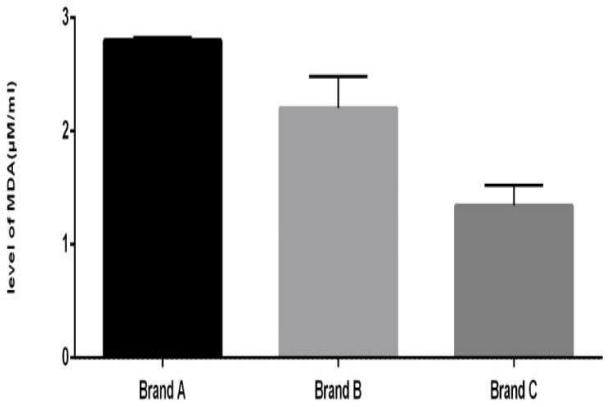

Figure 1. A comparison of MDA levels in different brands of industrial pasteurized ice cream. Data are presented as mean ± SD.

The average body weight 70 kg was considered. Estimated daily intake (EDI) was estimated 0.0042 µg/ kg according to this formula; EDI=(Ci×Cc)/BW

4. Discussion

In this study, the amount of MDA in ice cream with different brands in traditional and pasteurized industries was investigated. The traditional ice cream had a lower MDA level than industrial pasteurized ice cream, however the difference was not significant. The amount of MDA in the industrial pasteurized ice cream brands tested was very different. Brands A and B had much more MDA than brand C. with statistically significant difference ($P < 0.05$) was observed in MDA concentrations of brands C with A and B. A significant difference was not observed between A and B ($p=0.59$). Similarly, another study (21) also showed MDA as a byproduct of lipid peroxidation in ice cream, yogurt, meat, and fish. The results found that these products have adequate sources of toxic and carcinogenic chemicals in some dairy and fish products. The high content of unsaturated fatty acids in milk fat has been approved by increasing the risk of oxidation and off-flavors production (6). Furthermore, ice cream and dairy products are a good source of fat-soluble vitamins that are sensitive to oxidants(22-24).

In another study, Mahajan et al (2021) have examined the effect of edible films on the formation of lipid peroxidation byproducts in ice cream. The results showed MDA did not exceed the threshold limit of 1.0 mg Malondialdehyde/kg, but in samples that have edible film showed a significantly lower level than control samples (25). Similarly, this article showed the storage time had an impact on lipid oxidation and the formation of MDA.

MDA, an aldehyde compound that is unstable and highly reactive, is produced from unsaturated fatty acids peroxidation. The presence of MDA is usually associated with lipid peroxidation. If antioxidants are used to process these products, the resulting product will be healthier and more useful. The addition of antioxidants will increase oxidative stability. The oxidative stability of products with susceptible components such as unsaturated fatty acids can be achieved using various natural antioxidants. The antioxidant ingredients could prevent the presence of harmful MDA in final products. In a previous study, ice cream was fortified with an olein fraction of chia oil, and its antioxidant properties and oxidative stability were increased (26). In an investigation on source of MDA, Castillo et al. showed nutrition can influence the metabolites in raw milk like the production of MDA (27). The mean concentration of MDA in the industrial and traditional ice cream was calculated as 0.031 mg/kg. The daily ice cream consumption is about 9.5 g. The estimated dietary intake of MDA was calculated as 0.0042 µg/kg.

The standard maximum level for MDA has not been determined. The results of this study demonstrated that the level of lipid peroxidation could vary in different brands. Furthermore, with increasing storage time, the oxidation rate of these products will gradually increase. In this paper, the estimated dietary intake was calculated as 4.251 µg/kg, which is a considerable amount.

The acceptable daily values (ADI) for MDA or concentrations have not been compiled, and increasing levels of lipid peroxidation level in products are associated with various chronic diseases in humans like lung function and inflammatory markers (28-30). It is recommended to develop the maximum permissible MDA level in sensitive food products and rich in unsaturated fatty acids.

Conclusion

This study showed that the amount of MDA could be very different in branded samples. Furthermore, the dietary intake of MDA is considerable and requires preventive processing. Therefore, it is necessary to develop a standard regarding the permissible level of MDA in ice cream.

Conflict of Interest

The authors declare no conflicts of interest.

Acknowledgments

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