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Journal of Postharvest Technology
2024, 12 (2): 87-92
https://doi.org/10.48165/jpht.2024.12.2.09
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RESEARCH ARTICLE

Development of trans-free fat by interesterification

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ARTICLE INFO

Received : 23.02.2024
Accepted : 03.04.2024

ABSTRACT

THis research focuses on the development of trans-fat-free margarine to improve puff pastry quality while addressing health concerns. Extensive raw material analysis guided formulation, encompassing fatty acid composition, chemical attributes, color profiles, and flour characteristics. Central to the study was the interesterification process, enhancing shelf stability through vacuum drying, and employing sodium methoxide and citric acid for homogeneity, safety, and palatability. Bleaching elevated margarine quality. Comparing non-interesterified and interesterified margarine, peroxide values (2.47 vs. 0.99 meq/kg) and trans fatty acid content (1.81% vs. 0.21%) demonstrated a positive impact of interesterification. The application of the trans-fat-free margarine in puff pastry production revealed sensory preference for the interesterified version, boasting superior texture and flavor stability. In conclusion, this study successfully developed trans-fat-free margarine, optimizing parameters and enhancing its quality. This research contributes to healthier food choices, meeting consumer demand, and improving sensory quality and puff pastry stability.

Keywords: Trans-fat-free, interesterification, vacuum drying.

Citation: Patil, R. A., Shelar, D. N., Sahoo, A. K., Patil, S. A., & Udachan, I. S. (2024). Development of trans-free fat by interesterification. *Journal of Postharvest Technology*, **12** (2): 87-92.

INTRODUCTION

Fats and oils constitute fundamental components of our diet, serving diverse functions and exerting a profound impact on our overall health. These lipids, primarily triacylglycerols or triglycerides, are glycerol esters linked to three fatty acids, with the nature of these fatty acids significantly influencing the functionality of fats and oils (Vaclavik et al., 2014). Chemically, fats can be broadly categorized into four types: saturated, trans, cis-monounsaturated, and cis-polyunsaturated fatty acids. Their physical states at room temperature, with saturated and trans fatty acids being solid and cis-unsaturated fats liquid, play a crucial role in their utilization. Natural fats usually represent a mixture of these categories but are often categorized as 'unsaturated' or 'saturated' based on their predominant fatty acid type (Laclette et al., 2015).

Fats and oils have several vital roles in our diets, functioning as sources of energy, carriers for bioactive compounds and flavors, and solvents for essential nutrients, such as vitamins. In processed foods, fats also play a pivotal role in enhancing

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ISSN: 2348-4330

flavor, mouthfeel, and overall palatability, contributing to aroma and texture. Trans fatty acids (TFAs) are a specific category of unsaturated fatty acids formed primarily during partial hydrogenation, a common industrial process that raises fatty acid melting points, facilitating their use in products like margarine, shortening, vanaspati, and bakery fats (Stanley et al., 2009). The composition of fats, especially the types of fatty acids they contain, significantly influences their physical properties and health implications. Trans fats, in particular, are of concern due to their association with adverse health effects, notably an increased risk of coronary heart disease (CHD). As a result, regulatory measures have been implemented globally, including mandatory trans fat labeling, limits on trans fat content in cooking fats and oils, and bans on partially hydrogenated oils, a primary source of trans fats (Rader et al., 2013).

Replacing trans fats presents challenges as they possess unique functional characteristics challenging to replicate. Various modification techniques, such as interesterification, fractionation, and hydrogenation, are employed to achieve trans-fat-free or low-trans fat blends. Chemical interesterification, for instance, allows for the rearrangement of fatty acids within triglycerides, modifying their properties for specific applications (Asif et al., 2011). This study delves into the role of fats in food products, with a specific focus on bakery shortenings and their functionality in baked goods like pies, pasta, bread, and more. Additionally, it explores the health implications of trans fats and the importance of finding suitable replacements for them. Furthermore, the paper discusses the process of interesterification and its potential to improve the health profile of fats used in puff pastry and baked goods, contributing to the development of healthier food products (Wickramarachchi et al., 2015).

MATERIALS AND METHOD

Materials and chemicals

The acquisition of vital ingredients, such as all-purpose flour, sugar, margarine, butter, baking powder, and flavoring essence, adheres to rigorous quality standards at a nearby superstore or supermarket. This meticulous approach ensures that raw materials meet specific criteria for quality and purity, crucial in scientific research. Additionally, essential chemical reagents for raw materials like sodium methoxide and citric acid are easily obtained from the Food Technology Laboratory at Shivaji University, Kolhapur. This centralized source guarantees access to necessary analytical tools, facilitating a systematic examination and assessment of the materials and products under investigation.

Vacuum Drying

(120℃ for 60 min)

↓

Cooling up to 90℃

↓

Addition of Sodium Methoxide

↓

Resting for 30 min at 90℃

↓

Addition of Citric Acid

↓

Mixing up to 15 min

↓

Bleaching of oil

(0.75% bleaching earth 90℃ for 30 min)

↓

Filtration by Buchner filter

↓

Trans free fat

Fig. 1 Interesterification of fat blend for preparation of Trans free fat (Rodriguez *et.al*, 2009)

Interesterification of fat blend for trans free fat

Before initiating the interesterification process, a thorough analysis of the sle was conducted (Fig 1). This pre-process analysis was crucial for later comparisons with post-process results. The comprehensive analysis encompassed various tests to evaluate different aspects of the sle, providing a baseline understanding of its composition and characteristics.

Physiochemical Analysis

Before embarking on the interesterification process, a meticulous analysis of the initial sle was conducted. This critical introduction comprised a spectrum of detailed tests, exploring diverse aspects of the sle's composition, structure, and properties. The tests encompassed both chemical analyses, such as saponification value, iodine value, acid value, and peroxide value, as well as physical analyses, which include melting point determination of the fat. The comprehensive nature of these analyses encompassed factors such as molecular structure, chemical composition, and physical attributes. The purpose was not only to understand the initial state of the sle but also to discern the intricate changes induced by the interesterification process. Also, the fatty acid profile of margarine was evaluated. It was helpful to compare the quality of fat using both initial and final readings.

Effect of Sodium methoxide on interesterification of margarine

In this study, the production process of margarine was modified by incorporating various proportions of sodium methoxide to assess its impact on the peroxide value, an essential indicator of oxidation in fats and oils. Three distinct sles were prepared with varying quantities of sodium methoxide. These sles varied as follows: 100:0.2, 100:0.3, 100:0.5. This determination aimed at pinpointing the optimal ratio for minimizing oxidation, thereby enhancing the quality and extending the shelf life of the margarine product. By undergoing this optimization process, the aim was to ensure that the produced margarine exhibited superior quality, effectively mitigating issues such as rancidity and other oxidative concerns.

Effect of citric acid on interesterification of margarine

In the pursuit of optimizing the utilization of citric acid, various ratios were examined. Sles were created with different amounts of citric acid, aiming to identify the most effective ratio. The ratios of these sles were 100:1, 100:2, and 100:3. Citric acid played a crucial role in interesterification processes by acting as a neutralizing agent for potent alkali catalysts like sodium methoxide. Its function was to quench catalytic activity, allowing precise control of the reaction. Incorporated to adjust the pH to a neutral or slightly acidic level, citric acid ensured the stability and quality of modified fats or oils. The optimization process focused on refining the quantities of sodium methoxide used, highlighting the careful balancing needed to achieve the best possible outcomes during the interesterification process.

RESULTS AND DISCUSSION

The findings of this study are methodically presented and scrutinized across meaningful thematic areas, considering the available scientific literature and the analytical methodologies employed.

Effect of sodium methoxide on interesterification of margarine

Different proportions of sodium methoxide were analyzed for peroxide value in order to optimize sodium methoxide.

Table 1 : Effect of Sodium Methodixe on interesterified margarine

Sle	Margarine (%)	Sodium Methoxide (%)	Peroxide value (milliequi/kg)	Melting point (°C)
F1	100	0.2	1.87	39.6
F2	100	0.3	1.08	36.8
F3	100	0.5	0.96	32.9

In this process of interesterification, the catalyst used was sodium methoxide to accelerate the rate of reaction. It was observed that the peroxide value and melting point of sle F1 were high. Sle F2 had a lower peroxide value and melting point compared to sle F1. Sle F3 had an even lower peroxide value and melting point than sle F2. The peroxide value is a critical indicator of fat quality as it reflects its oxidation state. Lower peroxide values indicate fresher and less oxidized fats, making them more desirable. Additionally, fats with higher melting points are easier to handle during processing as they remain solid at higher temperatures. Taking these factors into consideration, "sle F2" was selected due to its low peroxide value indicating freshness and a higher melting point, making it the optimal choice for the intended application. The results were comparable to the work of Liu and Lert in 1999, who noted the use of 0.25 grams of sodium methoxide as a catalyst. In the present study, the optimized catalyst amount was 0.3 grams, which closely aligns with their specified value. This similarity in catalyst quantity suggests that the current study closely follows the methodology used in the earlier work by Liu and Lert.

Effect of citric acid on interesterification of margarine

Different ratios of citric acid were examined to assess their influence on both peroxide value and melting point. The objective is to optimize the utilization of citric acid for enhanced performance.

Table. 2: Effect of citric acid on interesterification of margarine

Sle	Margarine (%)	Citric acid (%)	Peroxide value (milliequi/kg)	Melting point (°C)
G1	100	1	1.75	39.1
G2	100	2	0.99	35.9
G3	100	3	0.94	32.2

In the analysis of various sles, two crucial parameters were examined: peroxide value and melting point. Sle G1 exhibited a peroxide value of 1.75, indicating a relatively high level of oxidative deterioration, while its melting point was 39.1, which was within an acceptable range for processing. Sle G2 had a lower peroxide value of 0.99, suggesting less oxidative damage, and its melting point was 35.9, still suitable for processing. In contrast, Sle G3 had a peroxide value of 0.94, not significantly different from G2, but its melting point was notably lower at 32.2, rendering it unsuitable for processing. Citric acid played a crucial role in this study by neutralizing the catalyst used in the interesterification process. Its addition was essential to adjust the pH to a neutral or slightly acidic level, ensuring the stability and quality of the modified fats or oils. The researchers were careful to avoid any adverse effects on the chemical properties of the fats during this process. In this analysis, Sles G2 and G3 exhibited similar peroxide values. However, G2 had a more favorable melting point. As a result, Sle G2 was chosen for further processing because it struck a balance between peroxide value and melting point that aligned with the desired criteria. These results are comparable with the results of Norizzah et al. (2018). It was noted that 2 grams of citric acid were used to neutralize the catalyst in 100 grams of margarine. This observation reinforces the consistent use of citric acid as a neutralizing agent across different studies and provides a reference point for its application in similar processes.

Effect of interesterification on Fatty acid profile of margarine

These detailed results provide valuable insights into the nutritional content of the margarine sles. The variations in the types and proportions of fatty acids in each sle are crucial, as different fatty acids can have varying effects on human health. This analysis sets the foundation for understanding the potential health implications of the margarine sles, laying the groundwork for further optimization or modification to enhance their nutritional profile.

Table 3: Effect of interesterification on Fatty acid profile of margarine

Parameter	Non-interesterified margarine	Developed Interesterified margarine
Saturated fatty acid (%)	57.56	49.73
Monounsaturated fatty acid (%)	23.26	31.67
Polyunsaturated fatty acid (%)	04.33	05.17
Trans fatty acid (%)	01.81	0.21

In this study, it was observed that non-interesterified margarine has a higher saturated fatty acid value compared to developed interesterified margarine. Saturated fatty acids have a high LDL, which is harmful to the human heart. Thus, the decrease in saturated fatty acid value in developed interesterified margarine signifies an increased quality of margarine. Similarly, monounsaturated and polyunsaturated fatty acids have increased in developed interesterified margarine. Unsaturated fats have a higher amount of HDL, which is beneficial for the human heart. Thus, increased unsaturated fatty acids add value to developed interesterified margarine. Trans fat present in non-interesterified margarine was higher. Higher trans fat content in margarine is harmful to the human heart. Higher trans fat can be responsible for cardiovascular diseases. Thus, developed interesterified margarine having low trans fat is less harmful to the human heart (Mozaffarian et al., 2006).

The study conducted by Samuel et al. in 2018 focused on evaluating the fatty acid profile following the interesterification process. Their research revealed a numerical increase of approximately 5.36% in polyunsaturated fats and 0.18% of TFA. Interestingly, research has yielded results that are in close agreement with these findings, indicating a similar increase in polyunsaturated fats after interesterification. This consistency in results strengthens the evidence that interesterification can effectively alter the fatty acid composition, specifically by increasing polyunsaturated fats, which may have positive implications for the nutritional quality of the product.

Effect of interesterification on chemical attributes of margarine

The main objective of this study was to reduce trans fat content while minimizing alterations in the chemical and physical properties of the sle. Consequently, this analysis facilitates the comparison of results. These comprehensive findings yield valuable insights into the chemical composition and quality of margarine sles, offering critical data on their fatty acid profiles, oxidative stability, and overall quality. This data plays a pivotal role in evaluating and guaranteeing the uniformity and quality of margarine in the food industry, enabling well-informed decisions related to production and product quality control.

Table. 4: Effect of interesterification on chemical attributes of margarine

Parameter	Non-interesterified margarine	Developed Interesterified margarine
Peroxide value (milliequi/kg)	2.47	0.99
Iodine value (g/100g)	70.85	72.31
Acid value (milliequi/g)	0.34	0.28
Saponification value (milliequi/g)	185.8	187.2

Peroxide value indicates the state of oxidation in fats or oils. A higher peroxide value indicates higher oxidation of fat. Therefore, the fat needs to have a lower peroxide value to maintain its freshness and quality. Here, developed interesterified margarine has a lower peroxide value compared to non-interesterified margarine. This indicates that developed interesterified margarine is more stable with respect to the oxidation of fat. The iodine value helps determine the presence of unsaturated fatty acids. Unsaturated fats are HDL, which are also known as healthy fats and are good for the human heart. Therefore, healthy fats need to have a higher iodine value, indicating a richness of unsaturated fat. Here, the iodine value of developed interesterified fat increased after the interesterification process. Thus, developed interesterified margarine is healthier compared to non-interesterified margarine. The acid value indicates the presence of free fatty acids in fat, which further helps in determining the rancidity of the fat. The lower the acid value, the more the fat is fit for consumption. This is because a higher acid value indicates more rancid oil and is unfit for consumption. Here, the acid value of developed interesterified margarine is lower compared to non-interesterified margarine. This indicates that developed interesterified margarine is fit and healthy for consumption. Considering all the above readings, it was observed that developed interesterified margarine is healthier and fit for consumption.

CONCLUSION

The research aimed to formulate trans-fat-free margarine, primarily achieved through interesterification. Vacuum drying removed residual water, and then sodium methoxide was added as a catalyst, followed by thorough mixing. Citric acid served as a neutralizing agent. After the process, the sle underwent bleaching to enhance its overall quality. This comprehensive approach improved the margarine's suitability for various applications. The study aimed to eliminate trans fat from margarine through interesterification with a focus on optimizing catalyst concentration and neutralization. Sodium methoxide served as the catalyst, with its concentration optimized to minimize peroxide values, indicative of fat quality. The peroxide value decreased from 2.47 milliequi/kg to 1.08 milliequi/kg post-interesterification, highlighting improved fat quality. Further optimization involved citric acid for catalyst neutralization, resulting in a peroxide value reduction to 0.99 milliequi/kg. Trans fat content decreased significantly from 1.81% to 0.21% after interesterification, indicating successful reduction. Moreover, saturated fat content decreased from 57.56% to 49.73%, making the margarine healthier for consumption. This comprehensive process not only lowered trans fat but also improved overall fat quality, rendering the margarine more suitable for consumption.

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