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Research Article

Strategic Mitigation of Dietary Acrylamide in Fried Plantains: Integrated Optimization of Frying Parameters and Citric Acid Pretreatment

Adams Abubakari[1]*, Isaac W. Ofosu[2], George Agana Akuriba[3], Abdul Aziz Bawa[4], Abdulai Sherif Bawa[5]

[1]Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

[2]Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

[3]Department of Entrepreneurship and Agribusiness, Cape Coast Technical University, Cape Coast, Ghana.

[4]Department of Food Science and Technology, University for Development Studies, Tamale, Ghana

[5]Department of Agriculture Biotechnology, University for Development Studies, Tamale, Ghana

E-mail: adamsabu135@gmail.com

Abstract

Acrylamide, a probable human carcinogen formed during high-temperature cooking of starchy foods, raises significant public health concerns. This study systematically examined acrylamide formation in fried plantains, a dietary staple in Ghana, focusing on the interactive effects of frying temperature (150–190 ºC), frying duration (3–9 minutes), and citric acid pretreatment concentration (10–20 g/L). Using response surface methodology (RSM), a quadratic model was developed that demonstrated an excellent fit (R^2 = 0.98) and high predictive reliability (adequate precision = 23.28) for acrylamide concentration. Results showed that frying at 190 ºC for 9 minutes resulted in acrylamide levels up to 9.51×10^2 µg/g, while pretreatment with 20 g/L citric acid significantly reduced acrylamide formation, lowering concentrations to as low as 6.5×10^1 µg/g. Mechanistic analysis indicated that citric acid lowers pH, protonates asparagine, and reduces its reactivity in the Maillard reaction, thereby suppressing acrylamide production. The optimal frying conditions identified were 150 ºC, a 3-minute frying time, and 20 g/L citric acid, under which acrylamide was predicted at 8.96×10^1 µg/g, well below typical local levels and comparable to international safety standards. However, frying above 180 ºC or for more than 6 minutes diminished the efficacy of citric acid due to accelerated thermal degradation pathways. This research provides practical and affordable interventions for reducing acrylamide in fried plantains, with implications for food safety policies and public health in Ghana and other regions where plantains are widely consumed.

Keywords: Acrylamide formation, Fried plantains, Citric acid pretreatment, frying temperature, Frying time, Food safety.

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INTRODUCTION

When foods high in carbohydrates are cooked at high temperatures, the reducing sugars react with the amino acid asparagine through the Maillard reaction. This process produces acrylamide, a heat-induced contaminant (Zhang et al., 2025). Acrylamide has gained worldwide concern because of its genotoxic and carcinogenic effects observed in animal studies, leading the International Agency for Research on Cancer (IARC) to classify it as "probably carcinogenic to humans" (Group 2A)(IARC, 1994). Most human exposures occur through diet, with significant sources including coffee, potato fries, bread, biscuits, and pastries. Children and teenagers are considered at higher risk due to their higher intake of these foods relative to their body weight.

Plantains are a staple food in many tropical regions and are often eaten as fried products. Frying improves flavor, aroma, and texture, but when performed at temperatures between 120–180 °C, it also encourages the formation of acrylamide (Teruel et al., 2015). Recent research has confirmed the presence of acrylamide in plantain-based foods. For example, reported concentrations as high as 894 µg/kg in ripe plantain chips, while Udomkun et al. (2021) demonstrated that ripening stage and precursor composition significantly influence acrylamide levels. These results are notable when compared to regulatory standards. The European Union (EU) has established benchmark levels of 500 µg/kg for French fries and 750 µg/kg for potato crisps and snacks (Regulation (EU) 2017/2158) (EU, 2017). Acrylamide levels in fried plantains are therefore comparable to, or sometimes higher than, those found in potato-based foods. Conversely, the U.S. Food and Drug Administration (FDA) has not set maximum limits; instead, it has issued guidance documents that focus on mitigation strategies (FDA, 2016). More widely, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) has concluded that no safe intake level for acrylamide can be defined and reaffirmed its classification as a probable human carcinogen (WHO, 2022). Collectively, these findings suggest that plantains might be a significant but understudied dietary source of acrylamide exposure.

In Ghana, frying is the predominant method of processing plantains, particularly for street-vended foods that all age groups consume. Acrylamide has already been detected in several other thermally processed Ghanaian foods, including roasted yams, peas, and potato chips (Mousavi Khaneghah et al., 2020; Liu et al., 2015). Despite this, little is known about acrylamide concentrations in fried plantains prepared under local processing conditions. Additionally, most processors lack awareness of acrylamide formation pathways and the potential role of pretreatments and frying parameters in mitigating its formation.

The present study was therefore undertaken to fill this knowledge gap by systematically investigating the effects of frying temperature, frying duration, and citric acid pretreatment on acrylamide formation in plantains. Response surface methodology (RSM) was employed to model and optimize these interactive factors. It was hypothesized that: (i) acrylamide levels increase with higher frying temperatures and longer frying times; (ii) citric acid pretreatment significantly reduces acrylamide formation; and (iii) an optimal set of processing conditions can be identified that minimizes acrylamide while preserving desirable product quality.

By generating evidence-based recommendations on frying practices and pretreatment strategies, this study aims to support processors and consumers in Ghana and other regions that consume plantains, while contributing to broader public health efforts to reduce dietary acrylamide exposure.

MATERIALS AND METHODS

Materials

Sources of raw materials

Ripe plantains were obtained from vendors at Kejetia market in the Kumasi metropolis within Ghana's Ashanti Region. Additionally, 24 samples of fried plantains were randomly collected from food vendors across eight different areas of the metropolis. The frying oil (Frytol brand, Wilmar Africa Ltd., Ghana) was purchased from a local retailer in Kumasi. Analytical-grade reagents, including citric acid and solvents, were sourced from Sigma Aldrich Company Limited.

Methods

This study investigated the influence of citric acid treatment, frying temperature, and frying time on acrylamide formation in fried plantains. Factor ranges were selected based on prior studies (Pedreschi et al., 2014; Mulla et al., 2017) and systematically randomized using Design-Expert® version 13 (Stat-Ease Inc., Minneapolis, USA) Table 1.

Table 1. Experimental Design Matrix Showing the Variation Levels of Frying Time, Temperature, and Citric Acid Concentration Applied to Plantain Samples for Acrylamide Analysis.

Factor	Variation levels
Frying time	3 – 9 min
Frying temperature	150 – 190 ºC
Citric acid treatment	10 – 20 g/l

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Preparation of raw materials

Fully ripened plantains were washed with tap water to remove adhering dirt and dust particles. The fruits were sorted, peeled, and the pulp rewashed to eliminate extraneous material. Following the procedure described by Bassama et al (2012), the plantain pulp was cut into slices of approximately 30 mm thickness. Citric acid solutions (10–20 g/L) were prepared by dissolving citric acid pellets in distilled water, as outlined in the experimental design (Table 2).

Citric Acid Soaking Treatment

Plantain slices were soaked for 30 minutes in citric acid solutions (10–20 g/L) at room temperature. After treatment, the slices were drained in a colander and prepared for frying, following methods previously used for acrylamide mitigation in plant-based foods (Mulla et al., 2017).

Deep Frying Treatment

Frying was carried out on an electric burner (Model GGPD2B-2201, China) using a non-stick frying pan. The oil was preheated to 150–190 °C and monitored using a mercury-in-glass thermometer. Frytol vegetable oil was used in sufficient quantity to fully immerse plantain slices. For each run, six slices were fried for 3–9 minutes, as specified in the design matrix. After frying, samples were removed, drained, cooled to room temperature, and blended (AKAI-BD052A-3156B, China) into a homogeneous mass. The ground samples were sealed in airtight bags for subsequent analysis of acrylamide.

Extraction and Clean-up for Acrylamide Determination

The extraction method followed a modified QuEChERS protocol optimized for acrylamide in fried products Five grams of the sample were weighed into an extraction tube, followed by defatting with petroleum ether. After centrifugation, the aqueous layer was extracted using acidified acetonitrile (1% acetic acid). A salt mixture of $MgSO_4$ and NaCl was added to enhance partitioning and remove co-extractives. Following phase separation, the acrylamide-containing fraction was collected and further cleaned prior to HPLC analysis.

HPLC Analysis

Acrylamide quantification was performed using an Agilent 1100 HPLC system equipped with a Variable Wavelength Detector (VWD). Separation was achieved on an Agilent Eclipse Plus C18 column (4.6 × 150 mm, 5 µm) maintained at 40 °C. The mobile phase consisted of acetonitrile: water (5:95, v/v), adjusted with orthophosphoric acid, at a flow rate of 1.0 mL/min. Detection was carried out at 225 nm, consistent with the protocol of Tareke et al. (2002). Calibration was achieved using external standards, and recovery tests were performed by spiking blank starch matrices with acrylamide. Method sensitivity was confirmed through the determination of the limit of detection (LOD) and the limit of quantification (LOQ).

Optimization of Processing Conditions for Frying Plantain

Design-Expert® v13 was employed for numerical optimization of frying conditions. The goal was to minimize

Table 2. Response Surface Methodology (RSM) design overview for frying plantains (Detailed run matrix retained as provided).

Runs	A: Time (min)	B: Temperature (ºC)	C: Citric acid concentration(g/l)
1	3	150	10
2	9	150	15
3	6	150	20
4	9	150	10
5	3	150	20
6	9	150	20
7	6	150	10
8	6	170	10
9	7.5	170	17.5
10	9	190	10
11	3	190	20
12	6	190	15
13	3	190	10
14	9	190	20
15	3	190	20
16	9	190	10
17	3	190	10
18	9	190	20
19	6	190	15

acrylamide levels while keeping frying temperature, time, and citric acid concentration within the set ranges (Pedreschi et al., 2014) (Table 3).

Statistical Analysis

Experimental data on acrylamide concentration were analyzed using ANOVA and regression analysis in Design-Expert® v13, with significance set at $p \leq 0.05$. Distribution fitting of acrylamide data (minimum, maximum, mean, median, 5th and 95th percentiles) was conducted using @Risk (student version). Modal acrylamide levels under optimal frying conditions were compared with responses at alternative processing settings.

RESULTS AND DISCUSSION

Model Fitting

A second-order (quadratic) response surface model was fitted to acrylamide concentration in relation to frying time (A), frying temperature (B), and citric acid concentration (C) using Design-Expert® v13. The overall model was highly significant (Table 4; $F = 46.41$, $p < .0001$), indicating that the factors explain a large portion of the variation in acrylamide levels. All three main effects were significant within the tested range. Temperature had the most substantial impact (B, $F = 167.85$, $p < .0001$), followed by time (A, $F = 136.42$, $p < .0001$), with citric acid concentration also being significant (C, $F = 12.10$, $p \leq .05$). This hierarchy (B > A > C) suggests that while acid pretreatment is effective, acrylamide formation is mainly influenced by thermal conditions (temperature and exposure time). Model diagnostics indicated the model was suitable for prediction and optimization. The lack-of-fit test was not significant ($F = 2.45$, $p = 0.2433$) relative to pure error, indicating that the selected model accurately captures the data trends (Dankwah et al., 2014). The coefficient of determination ($R^2 = .98$) and adjusted R^2 (.96) showed excellent fit, while the predicted R^2 (.84) was within acceptable bounds of the adjusted R^2, suggesting good external predictability without overfitting. The adequate precision of 23.28 greatly exceeds the standard threshold of 4, indicating a high signal-to-noise ratio and that the model can reliably explore the design space (Dankwah et al., 2014). In summary, these statistics demonstrate that the quadratic model provides a reliable and robust representation of acrylamide response over the studied ranges of time (3–9 minutes), temperature (150–190 °C), and citric acid concentration (10–20 g/L), making it suitable for response-surface-driven optimization.

The practical implications of these statistics are that they provide a solid basis for improving frying methods to reduce acrylamide in plantain products. According to the validated model, the optimal practices are to lower the frying temperature and duration. This finding aligns with results from systems that use potatoes and cereals (Mousavi Khaneghah et al., 2020; Zeng et al., 2020). Furthermore, the fact that citric acid pretreatment was identified as a significant factor suggests that simple, inexpensive interventions can further prevent acrylamide formation by decreasing precursor availability through pH adjustment (Pedreschi et al., 2014; Udomkun et al., 2021). The acrylamide levels found in fried plantains underscore the importance of such optimization when compared to the European Union benchmark levels of 500 µg/kg for French fries and 750 µg/kg for potato crisps (Regulation (EU) 2017/2158) (EU, 2017). Because fried plantains are a staple food in Ghana and other regions where plantains are consumed, processors and street vendors can protect public health by implementing optimal frying conditions and pretreatments Table 4.

Table 3. Optimization constraints for factors and response variables.

Factor	Goal	Lower limit	Upper limit	Importance
Time (min)	minimize	3	9	3
Temperature (ºC)	In range	150	190	3
Citric acid concentration (g/l)	In range	10	20	3
Acrylamide (µg/g)	minimize	$^*X_1$	$^*X_2$	3

Table 4. ANOVA for response surface quadratic model.

Source	Sum of squares	df	Mean square	F value	P – value prob > F	
Model	1487885	9	165321	46.41	0.0001	significant
A – Frying time	485972	1	485972	136.42	0.0001	
B – Frying temperature	597923	1	597923	167.85	0.0001	
C – Citric acid conc	42973.5	1	42973.5	12.1		
Residual	24936.1	7	3562.3			
Lack of fit	19100.1	4	4775.04	2.45	0.2433	not significant
Pure error	5835.95	3	1945.32			

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Influence of Temperature and Time on Acrylamide Formation

The interaction of frying temperature and time exerted a pronounced influence on acrylamide concentrations in fried plantain, ranging from 9.13×10^1 µg/g to 1.17×10^3 µg/g (Figure 1). Both factors were statistically significant contributors ($p \leq 0.05$) as confirmed in the ANOVA results (Table 4). The contour plots (Figure 1) demonstrate that acrylamide levels increased sharply with longer frying durations and higher temperatures, underscoring the role of thermal load as the primary driver of acrylamide synthesis. Comparative reports show variability in acrylamide accumulation in plantain and banana products. For instance, documented acrylamide concentrations ranging from 4.9×10^1 to 2.06×10^3 µg/g in deep-fried plantain chips, a range that partially overlaps with but is generally lower than that observed in the present study. This discrepancy may be explained by the exclusive use of ripe plantains in the current work. Ripe plantains are richer in reducing sugars compared to unripe or semi-ripe fruits, providing greater substrate availability for the Maillard reaction and, consequently, acrylamide synthesis (Pedreschi et al., 2014; Mulla et al., 2017). The strong temperature dependence of acrylamide formation aligns with prior studies in other starchy commodities. For example, Yang et al. (2016) reported that increasing frying temperatures in potatoes significantly elevated acrylamide content due to enhanced Maillard reaction kinetics. Similarly, Dankwah et al. (2014) demonstrated that roasted pigeon peas accumulated higher acrylamide levels at elevated temperatures, highlighting the universality of this phenomenon across diverse plant matrices. Time of exposure also exerted a marked influence, with acrylamide concentrations rising steadily from 3 to 9 minutes of frying. This pattern is consistent with kinetic studies, which show that acrylamide formation accelerates during the early stages of heating but continues to increase with prolonged exposure until degradation reactions (e.g., polymerization or binding to other matrix components) begin to dominate (Bassama et al., 2012; Friedman, 2003). In this study, no evidence of plateauing was observed within the tested range, suggesting that acrylamide accumulation in ripe plantains may progress linearly over the frying durations commonly applied in traditional preparation practices. All these scenarios combined confirm that thermal processing parameters strongly govern acrylamide formation in fried plantains. The data highlight the dual role of temperature and time as controllable levers for risk reduction: acrylamide levels were minimized at the lowest frying temperature (150 °C) and shortest time (3 min), particularly when coupled with citric acid pretreatment (see Section 3.3). These findings support the broader consensus that applying lower frying regimes can be an effective mitigation strategy without compromising the desirable sensory attributes of fried foods (Pedreschi et al., 2014; Taeymans et al., 2004) Figure 1.

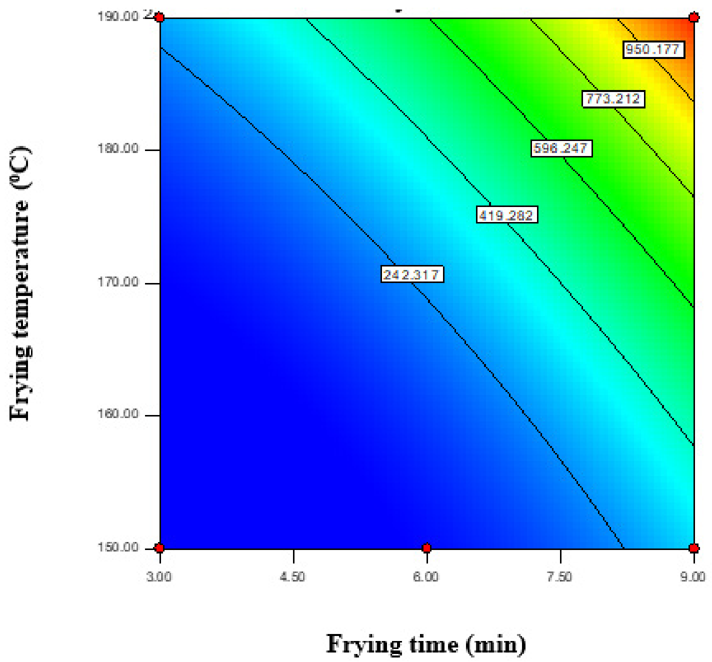

Figure 1: Response Surface Methodology (RSM) plot displaying the contour plots of the acrylamide concentrations (150 – 190 ºC) and time (3–9 min).

In the sub-sections that follow, we offer brief reviews of four main methods of online ethnography. Of course, these are by no means exhaustive in terms of this methodological domain, but they do represent major alternative approaches.

Performance of Citric Acid Treatment Relative to Acrylamide Content in Plantain

The interactive effects of citric acid concentration and frying time on acrylamide formation in plantains are shown in Figure 2. The response surface model indicates that acrylamide levels were highest at low citric acid concentrations but decreased progressively as citric acid concentration increased, reaching a minimum of 6.5×10^1 µg/g at approximately 20 g/L citric acid when the frying time was extended from 3 to 6 minutes. This trend confirms the suppressive role of citric acid in the formation of acrylamide. The reduction can be mechanistically explained by the acidification of the plantain matrix during citric acid pretreatment. Lowering the system pH increases protonation of carbonyl groups and the amino acid asparagine, thereby reducing their reactivity in the early stages of the Maillard reaction. Specifically, protonated asparagine exhibits decreased nucleophilicity, which hinders Schiff base formation, a key intermediate in acrylamide synthesis (Mottram et al., 2002; Stadler et al., 2002). This biochemical explanation aligns with the observed decrease in acrylamide levels at higher concentrations of citric acid. Similar inhibitory effects of organic acids on acrylamide formation have been reported in other food matrices. Liu et al., (2015) demonstrated that citric acid pretreatment reduced acrylamide levels in fried potato products by lowering the system pH and modifying the thermal breakdown pathways of asparagine. Likewise, Liyanage et al. (2021) confirmed the effectiveness of citric acid in decreasing acrylamide formation across starchy food systems, underscoring its potential as a mitigation strategy. However, while citric acid notably reduced acrylamide levels in this study, longer frying times partially countered its inhibitory effect, leading to a net rise in acrylamide levels beyond six minutes (Figure 2). This finding concurs with the results of Dankwah et al., (2014), who observed that extended thermal processing promotes ongoing Maillard reactions and acrylamide buildup despite pretreatment efforts to suppress them. Therefore, although citric acid is a promising, cost-effective agent for reducing acrylamide formation, its effectiveness is time-dependent and may be diminished by prolonged frying. Overall, the study's data support the potential of citric acid as a viable intervention to reduce acrylamide formation in fried plantain products. Nonetheless, optimization of both pretreatment concentration and cooking conditions is crucial to maximize its benefits in commercial settings Figure 2.

Influence of Citric Acid Concentration and Frying Temperature on Acrylamide Formation

The response surface plot in Figure 3 shows the combined effects of citric acid concentration and frying temperature on acrylamide formation in plantain chips. The lowest

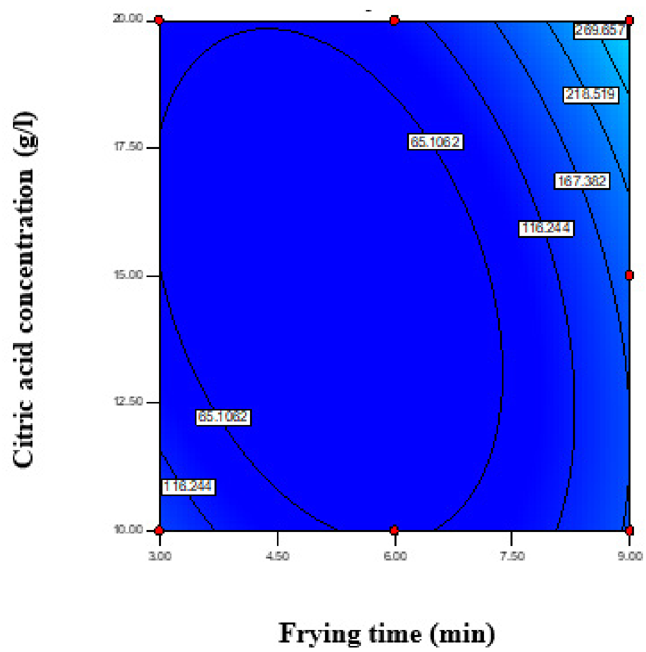

Figure 2: Response Surface Methodology (RSM) Contour Plot Illustrating the Effect of Citric Acid Concentration on Acrylamide Formation in Fried Plantain.

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acrylamide levels (6.3 × 10¹ µg/kg) were achieved when the citric acid concentration was between 15–20 g/L and the frying temperatures were maintained within the 150–180 °C range. Conversely, acrylamide levels increased significantly at higher frying temperatures (180–190 °C), especially when citric acid concentrations were limited to 10–12. 5 g/l. These patterns highlight that high citric acid concentrations combined with moderate frying temperatures are essential for minimizing acrylamide content in thermally processed plantain products. The inhibitory role of citric acid aligns with its pH-lowering effect, which diminishes the reactivity of asparagine and carbonyl compounds, thereby preventing the Maillard reaction pathway that leads to the formation of acrylamide (Mottram et al., 2002; Stadler et al., 2002). However, as frying temperatures exceed 180 °C, the thermal breakdown of reducing sugars and amino acids accelerates, leading to increased acrylamide formation, regardless of whether citric acid pretreatment is used. This indicates that temperature becomes the dominant factor once critical thresholds are exceeded, consistent with previous studies showing that acrylamide levels rise exponentially with increasing frying or roasting temperatures (Zhang & Zhang, 2007). Interestingly, the strong inhibitory effect of citric acid found in this study contrasts with that reported by Ofosu (2014), who found that citric acid had little impact on reducing acrylamide in roasted pigeon peas, with roasting temperature being the main factor. This difference may be due to variations in food composition: pigeon peas are rich in proteins and complex carbohydrates, while plantains contain higher levels of reducing sugars, which more readily react with asparagine to form acrylamide during thermal processing. Therefore, citric acid pretreatment may be more effective in starchy, sugar-rich foods, such as plantains, than in legume-based products. Overall, these results underline the combined importance of both citric acid concentration and frying temperature in reducing acrylamide. Maintaining frying temperatures below 180 °C and applying citric acid pretreatment provides a practical dual approach for reducing acrylamide in fried plantain products Figure 3.

Optimization of Frying Conditions

The optimal frying conditions for reducing acrylamide formation in plantain chips, as identified by response surface methodology (RSM), are summarized in Table 5. The best parameters were a frying temperature of 150 °C, a frying time of 3 minutes, and a citric acid concentration of 20 g/l. Under these conditions, the predicted acrylamide content was lowered to 8.96 × 10¹ µg/g, with a desirability index of 1.0, indicating an excellent model fit and high predictive reliability. The results show that citric acid pretreatment, combined with carefully controlled frying times and temperatures, is an effective strategy for reducing acrylamide in plantain-based products. Citric acid likely helps by lowering the pH and reducing the nucleophilic activity of asparagine, thereby decreasing its participation in the Maillard reaction pathway that produces acrylamide

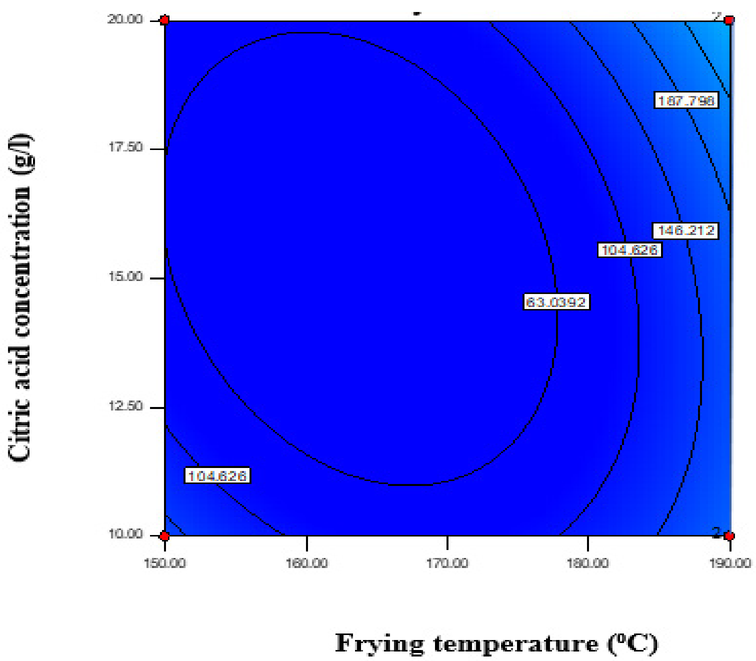

Figure 3: Correlation and Interaction between Citric Acid Concentration and Frying Temperature on Acrylamide Content in Plantain Chips, Demonstrated Through a Response Surface Plot.

Table 5: Response of Acrylamide Concentration (μg/g) in Plantain Samples Treated at Optimum Frying Conditions Including Citric Acid Concentration, Temperature, and Time.

Optimum frying process conditions			Response
Temperature	Time	Citric acid concentration (g/l)	Concentration of acrylamide
(ºC)	(min)		(μg/g)
150	3	20	8.96×10^1

Table 6: Statistical distribution of the elements of acrylamide in fried plantain from the study area.

Central tendencies and percentiles							
Variable	Statistical distribution	min	max	5th	Mean	Mode	95th
Acrylamide concentration (μ/g)	Pearson5 (4.3725,0.0018349, Shift (-0.0000686099)	4.9×10^1	4.3×10^3	7.0×10^1	2.09×10^2	1.03×10^2	5.03×10^2

(Mottram et al., 2002; Stadler et al., 2002). These findings are consistent with reports by Liyanage et al. (2021) and Liu et al. (2015), who demonstrated that acrylamide levels in heat-processed foods can be significantly lowered through a combination of pretreatments (such as citric acid application), process optimization (controlling time and temperature), cultivar selection, and storage management. The present study confirms that overall process optimization, notably by maintaining moderate frying temperatures and short frying durations, works synergistically with citric acid pretreatment to reduce acrylamide formation in plantain chips significantly.

Distribution of Acrylamide Content in Fried Plantain Samples

The distribution of acrylamide concentrations in fried plantain samples collected from the study area is summarized in Table 6. Acrylamide levels ranged from a 5th percentile low of 7.0×10^1 μg/g to a 95th percentile high of 5.03×10^2 μg/g, with a mean concentration of 2.09×10^2 μg/g. The most prevalent value (mode) was 1.03×10^2 μg/g, which provides a more representative estimate of the typical acrylamide content compared to the mean, given the skewed distribution of the data. Significantly, the acrylamide concentrations observed in these market samples far exceeded the European Union benchmark of 0.5 μg/g for fried plantain products. This highlights a potential public health concern, as uncontrolled frying practices appear to facilitate the excessive formation of acrylamide. When compared to the acrylamide concentration achieved under optimized frying conditions (8.96×10^1 μg/g; Table 5), the values obtained from market samples were markedly higher. The discrepancy can be attributed to the absence of process control during typical preparation—particularly in terms of temperature, frying duration, and pretreatment strategies such as citric acid immersion. According to the strict regulation of critical parameters—including frying temperature, processing time, pH adjustment, and asparagine reduction—is crucial for significantly reducing acrylamide formation in fried foods. The present findings therefore underscore the urgent need to promote controlled frying practices in plantain preparation across different settings in order to minimize consumer exposure to acrylamide.

Limitations and Sensory Considerations

Potential limitations should be considered, even though this study demonstrates that a citric acid pretreatment, combined with carefully regulated frying temperatures and times, can significantly reduce the formation of acrylamide in fried plantains. The availability of acrylamide precursor may be impacted by variations in plantain cultivars and ripening stages, which affect the amount of reducing sugars and asparagine. Additionally, although our results indicate significant mitigation potential, sensory attributes such as taste, texture, and aroma were not assessed and should be considered in future research to maintain consumer acceptance. By incorporating sensory analysis, the commercial viability of the suggested mitigation strategies will be more practically understood. Field tests with street vendors utilizing this optimized procedure are necessary because real-world frying setups differ significantly. Public health policies and regulatory frameworks aimed at reducing dietary acrylamide exposure in populations that rely on fried plantains as a staple food can be informed by these efforts Table 6.

CONCLUSION

This study clearly showed that frying temperature, frying time, and citric acid pretreatment all have a substantial impact on the formation of acrylamide in fried plantains. Higher temperatures and longer frying times were found to significantly increase acrylamide concentrations, which reached as high as 951 μg/g at 190 ºC for nine minutes. On the other hand, acrylamide formation was reduced considerably when plantain slices were pretreated with citric acid, lowering levels to as low as 65 μg/g. According to response surface optimization, frying at 150°C for three minutes and pretreating with 20 g/L citric acid reduces the amount of acrylamide to approximately 89.6 μg/g, which is significantly lower than the average concentration observed in local frying practices (210 µg/g). The results indicate that a practical and economical method to reduce dietary acrylamide exposure from fried plantain products, a staple in Ghana and other regions where plantains are consumed, is to employ controlled thermal processing in conjunction with mild acid pretreatment. Such measures are essential for consumer safety because acrylamide is likely carcinogenic and there are no known safe intake levels. The validity and dependability of these optimized conditions are further supported by the study's thorough statistical modelling and validation. To ensure consumer acceptance, it is crucial to strike a balance between acrylamide mitigation and sensory attributes, such as taste, texture, and appearance. This balance, as well as the long-term stability of frying oils under ideal circumstances, should be investigated in future studies. The study also emphasizes the necessity of raising local street food vendors' and processors' awareness of acrylamide hazards and practical mitigation strategies. Food vendors and legislators may be able to prepare popular street foods more safely by implementing these improved frying parameters and citric acid pretreatment techniques, which would ultimately enhance public health outcomes and food safety laws in Ghana and other comparable situations worldwide. Thus, this study supports healthier processing methods for fried plantain products and possibly other fried starchy foods, offering both scientific evidence and practical suggestions.

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