# *Original Research Article*

# Impact of Frying Oil Types and Keeping Duration on the Safety, Storability and Acceptability Factors of Chin-Chin (Deep-Fried Snack)


**ABSTRACT**

This study investigated the influence of frying oil types and storage duration on the acrylamide concentration, moisture variation pattern, thiobarbituric acid reactive substances (TBARS) content and acceptability factors of commonly consumed snack (chin-chin). A standard processing procedure was used to prepare the snack (chin-chin) using a combination of ingredients such as wheat flour, sugar, salt, margarine, ground nutmeg, egg, and water. Two types of vegetable oil used for deep-frying were soybean oil and refined palm olein oil while commercial chin-chin samples were also purchased to serve as the control. The results showed that during the storage period, the acrylamide contents in chin-chin samples exhibited gradual increase. The commercial chin-chin (CH-COM) contained the highest initial moisture content (13.54%) while all the chin-chin samples exhibited gradual increase in moisture content during the 12-day storage period. The study also revealed that during the storage period, all the chin-chin samples exhibited gradual reduction in the TBARS level. However, the degree of reduction in the TBARS content of commercial chin-chin was the highest as it reduced from the initial 0.33 mg MDA/kg to 0.17 mg MDA/kg during the 12-day storage duration. The fresh chin-chin samples exhibited relatively high level of browning index with significant differences at $p<0.05$ while there were variations in the oiliness index of the snack samples. The chin-chin samples in this study were generally found to satisfy the requirements for the tolerable levels for both the acrylamide and thiobarbituric acid reactive substances (TBARS) throughout the 12-day storage period.

***Keywords:*** Chin-chin, moisture variation, TBARS, acrylamide, vegetable oil.

## 1. INTRODUCTION

Chin-chin is a popular deep-fried snack in Nigeria and other West African countries. The production of chin-chin essentially involves using wheat flour, margarine, salt, sugar, milk and eggs; from which a stiff paste is made which is then deep-fried until golden brown colour and crispiness is developed [1, 2]. The product is usually cooled to ambient temperature (29±2$^{o}$C) after frying which is then followed by packaging into transparent high density polyethylene material. Chin-chin has a satisfying crunchy texture and a distinctive taste which consumers do enjoy [3]. An important peculiar attribute of snack foods, generally, is that they are usually consumed between or as an alternative to main meals [4].

There are usually variations in the type of vegetable oil being used for deep-frying which may include soybean oil, refined palm olein oil, and cotton seed oil, among others. The mode of sale of chin-chin in Nigeria is commonly done in the supermarkets and through roadside hawking. Being a deep-fried product, chin-chin is usually prone to acrylamide formation at relatively high temperature during deep-frying stage [5] which may constitute a safety concern; moisture variation [3] and lipid oxidation [6] during storage which may pose an important storability challenge; while inconsistent product quality concerns may also result due to diverse oil types involvement during frying. Acrylamide has been noted to be a heat-induced chemical contaminant which is formed during high-temperature processing such as frying, baking and roasting of various carbohydrate- rich and protein-rich foods [7]. Acrylamide has not been detected in unheated, raw or boiled food products while its formation in food is thus linked to exposure of foods to heating at high temperatures in the range of 130 to 190$^{o}$C [8]. Acrylamide is essentially a chemical compound whose toxicological properties have been found to include being a potential human carcinogen as well as a human toxicant [9, 10]. Due to its low molecular weight and polarity, it is rapidly circulated via the human blood stream and can be found in the liver, kidney, thymus, brain, heart and human breast milk [11].

Both moisture variation and lipid oxidation are major indicators that influence shelf life stability of the snack food while other factors such as colour and oiliness index of the fried food product can significantly influence the degree of acceptability by the consumers [4]. The moisture content within a food matrix has been observed of capable of influencing such characteristics as microbial safety, chemical and biochemical reactivity, and physical properties, among others [12]. Lipid oxidation, on the other hand, is a major cause of deterioration of fat-containing food matrix, particularly those containing polyunsaturated fatty acids [13]. The use of thiobarbituric acid reactive substances (TBARS) as a standard marker for the assessment of degree of lipid oxidation in fat-containing food matrix is now commonly carried out [14]. Therefore, the major focus of this study was to investigate the influence of frying oil types and keeping duration, at ambient conditions, on the safety, storability and acceptability factors of chin-chin, which is a popular food snack in Nigeria.

## 2. MATERIALS AND METHODS

### 2.1 Materials

The major ingredients (wheat flour, salt, margarine, sugar, milk, and eggs) used for chin-chin production were obtained from a local market (King's market, Akure, Nigeria). All reagents used were of analytical grade.

### 2.2 Ingredient formulation and production of chin-chin

The ingredient formulation (Table 1) for chin-chin production as well as the processing procedures as described by Emelike and Ebere [3] was adopted. Two hundred grammes (200 g) of wheat flour were weighed and sieved using 250 micron sieve aperture into a clean bowl.

**Table 1.** Ingredient formulation for chin-chin production.

| **Ingredient** | **Proportion** |
|---|---|
| Wheat flour (g) | 200 |
| Margarine (g) | 50 |
| Sugar (g) | 50 |
| Egg (g) | 47.8 |
| Milk (g) | 20 |
| Baking powder (g) | 11.2 |
| Water (mL) | 100 |

(Source: Emelike and Ebere [3]).

All dry ingredients such as sugar, salt and baking powder were weighed and sieved into the bowl and mixed with water thoroughly to ensure uniformity. Margarine was rubbed-in while a mixture of egg and milk were turned in and mixed to form dough. The dough was placed on a floured surface and kneaded until smooth and elastic mass was obtained. The kneaded dough was rolled out to approximately 2 cm thick layer and then cut into small squares of about 2 cm by 2 cm in size. Vegetable oil (soybean oil or refined palm olein oil) was put inside a deep fryer (Mikachi Deep Fryer S-515) and allowed to heat until the temperature of the fryer reached 180$^{o}$C. Dough cubes were placed in the hot vegetable oil and the chin-chin was deep fried for 5-8 min until golden brown colour was obtained. The fried chin-chin was removed and drained from excess vegetable oil, cooled to ambient temperature (29±2$^{o}$C) and then packaged using transparent high density polyethylene bags. The packaged chin-chin samples were later stored under ambient conditions (29±2$^{o}$C; 65-75% relative humidity) for subsequent evaluation. Chin-chin samples from commercial producers were also collected from the point of production to serve as the control samples.

### 2.3 Determination of acrylamide in chin-chin samples during storage

The spectrophotometric method of Chong *et al.* [15] was used for acrylamide determination. Acrylamide stock solution (100 ppm) was first prepared by dissolving 0.01 g acrylamide powder in de-ionized water inside a volumetric flask and topped to 100 ml mark. Lower concentrations of acrylamide solutions (5-30 ppm) were prepared by appropriate dilutions from the stock solution. Similarly, Nessler's reagent [potassium tetraiodomercurate (II)] was prepared by mixing mercury iodide ($HgI_2$) and potassium iodide (KI) at a molar ratio of 1:2 (0.075 M of $HgI_2$ with 0.15 M of KI). Thereafter, a standard curve was obtained as follows: 2 mL of a known acrylamide concentration (0-30 ppm) was first hydrolyzed using 2 mL of 6.0 M NaOH and left for 10 min in a test tube. The ammonia produced was determined using 5 mL of 3.0 mM Nessler's reagent and left for 5 min for the formation of mercury (II) amido-iodide complex. The absorbance of the complex was measured using UV-Vis spectrophotometer (Spectrophotometer UV5; Mettler Toledo, India) at the wavelength of 420 nm. A blank sample was also analyzed using only distilled water with no acrylamide. A standard curve was obtained by plotting absorbance values against the acrylamide concentrations.

For the actual acrylamide determination in chin-chin samples, the food product was first pulverized (ground) using a variable-speed Waring blender prior to sampling. One gramme (1.0 g) of ground sample of chin-chin obtained from each oil type was respectively weighed into a 50 mL polypropylene tube followed by the addition of 10 mL distilled water. After 10 min, the moistened sample was vortexed and then mixed thoroughly on an orbital shaker. The mixture was centrifuged at 9000 rpm and temperature of $5^{o}C$ for 10 min followed by the filtration of a 3 mL aliquot of the supernatant through a 0.45 μm nylon filter. Thereafter, 2 mL of the filtrate was placed in a test tube and then hydrolyzed using 2 mL of 6.0 M NaOH and then left for 10 min. Five millilitres (5 mL) of 3.0 mM Nessler's reagent was added to the hydrolyzed sample and left for 5 min after which the absorbance of the complex formed was measured at a wavelength of 420 nm using UV-Vis spectrophotometer (Spectrophotometer UV5; Mettler Toledo, India).

### 2.4 Determination of moisture variation in chin-chin samples during storage

This method used was based on measuring the weight loss by foods due to the evaporation of water [16]. The moisture content was measured carefully by respectively weighing out 2 g of ground sample of chin-chin obtained from each oil type into clean and dry glass petri dish with lid and known weight ($W_1$). The total weight of the sample and the container with lid was recorded as $W_2$. The sample and the container with lid were then placed into a drying oven operated at 105 °C for 3 hours. The sample was then placed in a desiccator, where it was cooled for approximately 30 min, and then weighed ($W_3$)

$$\% \text{ Moisture content in sample} = \frac{W3-W1}{W2-W1} \times 100 \qquad \text{Eq (1)}$$

## 2.5 Determination of thiobarbituric acid reactive substance (TBARS) in chin-chin samples during storage

The thiobarbituric acid reactive substance (TBARS) content of chin-chin samples under storage was determined using the method of Witte *et al.* [17]. Ten grammes (10 g) of ground sample of chin-chin obtained from each oil type were respectively measured into a 100-mL beaker followed by the addition of 20 mL of 10% trichloroacetic acid (TCA). The mixture was then subjected to magnetic stirring for 3 min after which the mixture was cooled to 4$^{o}$C. The cooled mixture was then transferred into a centrifuge (Eltek Centrifuge, MP 400R, Electrocraft, India) where centrifugation was done at 600 rpm for 5 min. After centrifugation, the supernatant was filtered through Whatman #1 filter paper. One millilitre (1 mL) of filtrate was then combined with 1 mL of 0.02 M acqueous 2- thiobarbituric acid solution (TBA) in a test tube, heated in a boiling water bath for 20 min together with a blank containing 1 mL of a TCA/water mix (1/1) and 1 mL of TBA reagent and subsequently cooled under running tap water. The samples were analyzed in triplicate and the results were expressed as milligramme malondialdehyde per kg sample (mg MDA/kg sample), using a standard curve that covered the 1 mM to 10 mM 1,1,3,3- tetramethoxypropane concentration range (Sigma-Aldrich, Steinheim, Germany). The absorbance value was measured at 532 nm with UV-Vis spectrophotometer (Spectrophotometer UV5; Mettler Toledo, India) against a blank that contained all the reagents together with 1 mL distilled water.

## 2.6 Determination of colour characteristics of freshly produced chin-chin samples

The colour of chin-chin from each oil type was measured using a colour measuring instrument (Minolta, Model CR310, Osaka, Japan) and the values expressed on the L*, a*, b* tristimulus scale. The L* value signifies lightness, where L* = 0 is completely black and L* = 100 is completely white. The a* values represent red to green with (+a*) and (-a*) depicting red and green, respectively. The b* values also represent yellow to blue, with (+b*) representing yellow and (-b*) representing blue [18]. The instrument was initially calibrated using a white reference standard, white duplicating paper sheet, 80g/$m^2$ (L*=93.41, a*= +1.32, b*= +0.08). The chin-chin sample was put on aluminum foil on a flat surface and the colour meter was placed on the sample by allowing the sensor to touch it. The reading was taken directly and the results from three replicates per sample were averaged. The browning index (BI) of chin-chin was calculated from the L*, a*, b* tristimulus scale and used to describe the brown colour characteristics of the sample [19].

$$\text{Browning Index (BI)} = \frac{[100(x-0.31)]}{0.17} \qquad \text{Eq (2)}$$

where,

$$x = \frac{(a*+1.75L*)}{(5.645L*+a*-3.012b*)} \qquad \text{Eq. (3)}$$

## 2.7 Determination of oiliness index of freshly produced chin-chin samples

The chin-chin samples obtained from each oil type were evaluated for their index of oiliness using the modified procedures of Bolade [4]. This was determined by positioning the square-shaped chin-chin sample (about 2 cm by 2 cm) at the centre of a large white filter paper (18 cm in diameter) which was also placed on a flat, non-absorbent platform. The central point of the sample was noted while the chin-chin sample was left to stay on the filter paper for 2 h after which the circular spread of the oil absorbed by the filter paper was measured. The index of oiliness in the sample was taken as the total circular area ($cm^2$) occupied by the oil absorbed by the filter paper from the sample. The experiment was carried out in triplicates while the average total circular area occupied by the absorbed oil was taken as the actual index of oiliness ($cm^2$) of the sample. This analysis assumed a circular movement of the absorbed oil.

*Calculation:*

Index of oiliness ($cm^2$) = Total circular area occupied by the absorbed oil

$$= \pi R^2 \qquad \text{Eq. (4)}$$

where;

R = outer radius of circular distance travelled by the absorbed oil (cm)

$\pi$ = constant factor (3.142)

## 2.8 Statistical analysis

All determination were carried out in triplicate and statistical analyses were done using Analysis of Variance (ANOVA) and Duncan's New Multiple Range Tests (DMRT) was used to compare the means at $P=0.05$ using Statistical Package for Social Scientists (SPSS) software, version 21. The graphical illustrations were carried out using Microsoft Excel.

# 3. RESULTS AND DISCUSSION

## 3.1 Safety status of chin-chin via acrylamide content as influenced by frying oil types and keeping duration

The changes in the acrylamide content of chin-chin, deep-fried with two types of vegetable oil, during storage period is presented in Figure 1. The acrylamide content of freshly

CH-COM=Commercial chin-chin sample.
CH-SOY= Chin-chin from soybean oil.
CH-RPO= Chin-chin from refined palm olein oil.

**Figure 1.** Changes in acrylamide content of chin-chin during storage.

produced chin-chin ranged between 119.61 and 182.81 mg/kg; with chin-chin from soybean oil (CH-SOY) exhibiting the lowest value while that from the commercial producers (CH-COM) exhibited the highest value. The variability in the acrylamide contents may be attributed to the varying intensities of heat transfer from the vegetable oil types used in deep-frying. Earlier observations had revealed that deep-frying essentially involves the immersion of food material in edible oil for a few minutes at high temperature between 130 and 190 $^{o}$C at atmospheric pressure [20] while it also involves simultaneous transfer of heat and mass [21]. Therefore, higher intensity of heat transferred during deep-frying could lead to greater synthesis of acrylamide in the food products [22]. Furthermore, vegetable oils with lower heat transfer coefficients had been observed to be capable of producing lower acrylamide concentrations compared to those with higher heat transfer coefficient as they produce higher acrylamide concentration during frying [23].

During the 12-day storage duration of chin-chin, the acrylamide contents in the food products were generally observed to undergo gradual increase. The chin-chin from soybean oil (CH-SOY) exhibited an increase in acrylamide content from 119.61 to 125.53 mg/kg, giving an overall incremental level of 4.9%; that from refined palm olein oil (CH-RPO) exhibited an increase from 176.02 to 178.8 mg/kg, giving an overall incremental level of 1.6%; while that from the commercial producers (CH-COM) increased from 182.81 to 187.07 mg/kg, giving an overall incremental level of 2.3%. The general gradual increase in the acrylamide concentration in the food products during keeping period may be attributed to a seeming further interaction between amino acids (aspargine) and reducing sugars (glucose) within the food matrix during the storage period at ambient conditions. An earlier observation had indicated that acrylamide is essentially a Maillard reaction product that is synthesized from amino acids (aspargine) and reducing sugar (glucose) at a higher processing temperature, usually between 130 and 190$^{o}$C [24]. It therefore seems that the already initiated reaction continued at a slow rate even during storage. The nutritional safety significance of acrylamide in the chin-chin product, as found in this study, is that the concentrations are generally lower than the tolerable level of 40 mg $kg^{-1}$/kg body weight/day. Tardiff *et al.* [10] had indicated that the tolerable daily intake of acrylamide to avoid its neurotoxicity was put at 40 mg $kg^{-1}$/kg body weight/day while that to avoid its carcinogenic influence was put at 2.6 mg $kg^{-1}$/kg body weight/day.

### 3.2 Storability factors of chin-chin as influenced by frying oil types

The influence of frying oil types and storage duration on the moisture content of chin-chin is presented in Figure 2. The moisture content of freshly-produced chin-chin from all the sources ranged from 11.29 to 13.54 g/100g. The commercial chin-chin sample (CH-COM) was observed to exhibit the highest moisture content and this may be attributed to certain traditional beliefs peculiar to the commercial practice in chin-chin production. This involves a desire to produce more quantity within a short period thereby not allowing the food product to dry properly during deep-frying. The responses of the packaged chin-chin to moisture uptake during storage revealed that there was a general gradual increase in their moisture contents throughout the 12-day storage period. The chin-chin sample from soybean oil (CH-SOY) was observed to exhibit an overall moisture increase of 3.6% (from 11.86 to 12.29 g/100g); that from refined palm olein oil (CH-RPO) had an overall moisture increase of 15.9% (from 11.29 to 13.09 g/100g); while that of commercial chin-chin (CH-COM) exhibited an overall moisture increase of 13.7% (from 13.54 to 15.4 g/100g). The interpretation that may be given to this occurrence is that the botanical origin of vegetable oil might have played a major role in the degree of moisture absorption by the deep-fried food product while the packaging material used (transparent high density polyethylene bag) remained the same. The vegetable oils from different botanical origins had been observed to

CH-COM=Commercial chin-chin sample.
CH-SOY= Chin-chin from soybean oil.
CH-RPO= Chin-chin from refined palm olein oil.

**Figure 2.** Changes in the moisture content of chin-chin during storage.

possess diverse properties due to their fatty acid and glyceride composition [25] while fried food products containing short and unsaturated fatty acids could easily be penetrated by water than those with long and saturated fatty acids [26]. The technological significance of moisture content in food products generally is that it is capable of influencing such characteristics as microbial safety, chemical and biochemical reactivity and physical properties, among others [12].

Figure 3 shows the changes in thiobarbituric acid reactive substances (TBARS) content of chin-chin, fried with two types of vegetable oil, during storage period. The freshly produced chin-chin exhibited TBARS values that ranged between 0.29 and 0.33 mg MDA/kg; with chin-chin from refined palm olein oil (CH-RPO) having the lowest value and that of commercial sample (CH-COM) had the highest value. This occurrence revealed that a freshly produced chin-chin might not be free of TBARS. The TBARS content is regarded as an indicator of the degree of secondary decomposition products of hydroperoxides present in fat-containing food products [27]. During the 12-day storage period of chin-chin, the TBARS contents were generally observed to decrease in values. The chin-chin from refined palm olein oil (CH-RPO) had a reduction in TBARS content from 0.29 to 0.21 mg MDA/kg, giving an overall reduction level of -27.6%; that from soybean oil (CH-SOY) reduced from 0.31 to 0.26 mg MDA/kg, giving an overall reduction level of -16.1%; while that of commercial sample (CH-COM) exhibited a reduction from 0.33 to 0.17 mg MDA/kg, giving an overall reduction level of -48.5%. The reduction in the TBARS content of chin-chin during storage may be attributed to possible interactions of TBARS with the endogenous food components such as proteins and amino acids. It had earlier being observed that the secondary decomposition products from hydroperoxides such as aldehydes, dialdehydes, epoxides and malondialdehyde, which constitute the reactive substances, could further interact with proteins and amino acids [28].

CH-COM=Commercial chin-chin sample.
CH-SOY= Chin-chin from soybean oil.
CH-RPO= Chin-chin from refined palm olein oil.

**Figure 3.** Changes in thiobarbituric acid-reactive substances (TBARS) content of chin-chin during storage.

These interactions might therefore lead to the reduction in the TBARS concentrations. However, the differences in the degree of reduction of TBARS values in the deep-fried food products may also be attributed to the varying responses of these TBARS, from vegetable oils of different botanical origins, to such interactions. The lipid oxidation leading to the secondary decomposition of hydroperoxides had been viewed as one of the factors causing the deterioration of fat-containing food products especially those containing polyunsaturated fatty acids [13]. The nutritional significance of TBARS as found in the chin-chin products of the present study is that the values are generally lower than the acceptable maximum limit of 1.0 mg MDA/kg [29].

### 3.3 Acceptability factors of chin-chin as influenced by frying oil types

The colour and degree of oiliness of chin-chin play a major role in consumers' acceptability of the snack. Table 2 presents the colour characteristics and oiliness index of freshly produced chin-chin. The lightness index (L*-value) of all the chin-chin samples was generally low (58.25-60.94) but this variable may not be regarded as the appropriate indicator for describing the colour change in chin-chin, being a deep-fried food product that is prone to browning reaction. The a*-values of the chin-chin samples ranged between 8.91 and 9.06 with no significant difference at $P<0.05$. The a*-values were all in the positive region which implies that the samples exhibited traces of reddish colour as opposed to greenish colour (negative a*-value). The b*-values of CH-COM (commercial chin-chin sample) was the highest (46.13) followed by those of CH-RPO (chin-chin from refined palm olein oil) and CH-SOY (chin-chin from soybean oil), giving 46.07 and 44.59 respectively. The b*-values were all in the positive region which implies the presence of traces of yellowness as opposed to bluish colour (negative b*-value).

**Table 2.** Influence of frying oil types on the colour characteristics and oiliness index of freshly produced chin-chin[1].

| Source of samples | Colour characteristics | | | | Oiliness index ($cm^2$) |
|---|---|---|---|---|---|
| | **L*** | **a*** | **b*** | **Browning index (BI)** | |
| CH-COM | 58.25±0.09$^c$ | 9.06±0.11$^a$ | 46.13±0.56$^a$ | 145.9±1.7$^a$ | 9.51±0.16$^c$ |
| CH-SOY | 60.94±0.04$^a$ | 8.91±0.06$^a$ | 44.59±0.49$^b$ | 128.6±1.5$^c$ | 21.65±0.12$^b$ |
| CH-RPO | 59.27±0.05$^b$ | 9.02±0.04$^a$ | 46.07±0.32$^a$ | 141.4±1.8$^b$ | 27.01±0.09$^a$ |

[1]Results are mean values of triplicate determination ± standard deviation. Mean value within the same column having the same letter are not significantly different at *P=0.05*.

CH-COM=Commercial chin-chin sample.
CH-SOY= Chin-chin from soybean oil.
CH-RPO= Chin-chin from refined palm olein oil.

The browning index (BI) of chin-chin samples exhibited a range of 128.6 - 145.9 with CH-COM (commercial chin-chin sample) having the highest value while CH-SOY (chin-chin from soybean oil) had the lowest value, with significant differences at $P<0.05$. The browning index (BI) could be regarded as the most useful indicator for describing the colour change in chin-chin because of some degrees of browning expected in the deep-fried snack. The variation in the browning index values of chin-chin samples therefore may be attributed to different frying oil types involved. This is, most probably, due to vegetable oils from different botanical origins containing diverse properties by virtue of their fatty acid and glyceride composition [25]. The brown colour development in chin-chin usually occurs during the frying operation and may be attributed to caramelisation and/or Maillard reaction occurring within the ingredient matrix [30]. Therefore, the degree of brown colour formation in chin-chin could play an important role in the consumers' acceptability of the snack food [31].

The oiliness index of chin-chin samples from all frying oil types, as shown in Table 2, revealed that the commercial chin-chin samples (CH-COM) exhibited the lowest value (9.51 $cm^2$) while that from refined palm olein oil (CH-RPO) exhibited the highest value (27.01 $cm^2$). The reason for this observation may also be attributed to the chemical composition of the oil types involved in the frying operation. An earlier observation had revealed that the fatty acids component of vegetable oil could undergo autoxidation thereby leading to the formation of such products as aldehydes which usually possess oiliness/greasiness properties [32]. Therefore, the degree of oiliness as exhibited by the chin-chin samples could be related to the level of aldehydes formed through autoxidation of fatty acids in the respective frying oil types. The oiliness index could influence the level of consumers' acceptability of the snack and it essentially reflects the amount of oil capable of migrating from the product into its surrounding environment such as packaging materials or consumer's palm or fingers when handled [4].

## CONCLUSION

The conclusion from this study is that both the frying oil types used for chin-chin production as well as the keeping duration did have significant influence on the safety, storability and acceptability factors of the snack food. These factors were reflected in the acrylamide level, moisture uptake pattern, thiobarbituric acid reactive substances (TBARS) concentration, colour variation and oiliness index in the food product. There was a gradual increase in both acrylamide level and moisture content in the chin-chin during storage while a gradual decrease was observed for thiobarbituric acid reactive substances (TBARS) during storage. The fresh chin-chin exhibited relatively high level of browning index with significant differences at $P=0.05$ while there were variations in the oiliness index of the snack samples. The chin-chin samples in this study were generally found to satisfy the requirements for the tolerable levels for both the acrylamide and thiobarbituric acid reactive substances (TBARS) throughout the 12-day storage period.

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