# INVESTIGATING THE EFFECTS OF BAKING PARAMETERS ON PROXIMATE, MINERALS AND VITAMIN C COMPOSITIONS OF CRACKERS

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***ABSTRACT***
This study investigated the effects of three baking parameters - pawpaw puree concentration, fermentation duration and baking temperature - on the proximate, minerals and vitamin C compositions of crackers. Ripe pawpaw puree was used as substitutes for fat at 0, 25 and 50% respectively. Crackers were fermented for 1, 2 and 3 hours and baked at temperatures of 130, 150 and 170ºC respectively. Proximate compositions of crackers showed that the moisture contents ranged from 1.08-4.28%, ash (2.11-2.31%), fat (3.09-4.09%), protein (10.17-12.51%), crude fibre (1.19-1.66%) and carbohydrates (75.47-82.11%). The results also showed the presence of some minerals such as calcium (180-241 mg/100 g), magnesium (24.90-36.82 mg/100 g), sodium (423.1-488.2mg/100 g) and potassium (122.8-220.8 mg/100 g). Vitamin C compositions of the cracker samples were observed to be within the range of 9.81 to 16.32 mg/100 g. The study showed that ripe pawpaw puree could be used as supplement for fat at suitable fermentation durations and baking temperatures without adversely affecting the qualities of the crackers.
**KEYWORDS*:*** Baking temperature, Calcium, Fermentation duration, Pawpaw puree, Ready-to-eat (RTE) snacks

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## 1. INTRODUCTION

The demand of healthy, ready-to-eat (RTE) snacks by consumers has given rise to the production of varied nutrient-fortified crackers with the incorporation of fruit puree and other alternative healthy fats. Currently, fast food snacks particularly crackers are known to be popular items to consumers of all age groups. This is due to the fact that they are handy, light, having unique flavour and texture and can be eaten between regular meals or in occasions as light refreshment (Akonor et al., 2016; Pillai & Shekhar, 2021). Reports have shown that various types of cracker snacks are widely consumed and generally acceptable in many countries of the world (Indrianingsih et al., 2019; Khatun et al., 2016). This is possible because of their many advantages such as longer shelf life, attractive appearance, convenience, very low sugar content, variety and low production cost (Goubgou et al., 2021; Maia et al., 2021; Qadri et al., 2018; Uchegbu & Ishiwu, 2015).

Notwithstanding the acceptability and benefits of ready-to-eat (RTE) cracker snacks, they must be consumed in moderation as high intake can be lethal to human health and exposed the consumers to several cardiovascular and degenerative disease as a result of the less fibre and excess fat contained in them (Khatun et al., 2016). To combat this problem, a lot of healthy ingredients such as fruit puree/flour (Khatun et al., 2016; Maseko et al., 2024), vegetable pomace (Isik & Topkaya, 2016; Kuchtová et al., 2016), modified grain flours and seeds blend (Indrianingsih et al., 2019; Olagunju et al., 2018; Qadri et al., 2018), bio calcium and protein hydrolysate powders from fish origin (Benjakul & Karnjanapratum, 2018; Idowu et al., 2019), edible insect flour (Akullo et al., 2018; Djouadi et al., 2022) and many other biomaterials have been incorporated in different studies to partially replace the unhealthy ingredients, especially the excess fats. These ingredients also helped to fortified some nutritional and functional qualities of crackers and make them suitable for consumers with varied health needs.

Pawpaw (*Carica papaya L*) belongs to the group of tropical fruits are rich in antioxidants such as polyphenols and carotenoids, vitamins and minerals It is a large herb belonging to the family Caricaceae and is widely cultivated, and sometimes grows uncultivated in many tropical countries of Africa and the world at large (Adepoju et al., 2021). Unfortunately, ripe pawpaw rapidly undergoes series of undesirable changes leading to huge deterioration after harvesting. Also, it has as not been exploited much for processing as it is mostly consumed as fruit when ripe or left to waste (Vasanthakaalam et al., 2018). Therefore, utilising pawpaw in various processed products such as cracker snacks will help to minimize the postharvest losses. This offers great potentials for both the farmers, snack processing industry and consumers alike as pawpaw is cheap and readily available in most months of the year and are heathy to consume. This present study seeks to investigate the effects of three baking parameters - pawpaw puree concentration, fermentation duration and baking temperature - on the proximate, minerals and vitamin C compositions of crackers.

## 2. MATERIALS AND METHODS

### 2.1 Materials

Ripe pawpaw fruits used for the preparation of puree were obtained from the University road fruit market. Other ingredients including commercial whole-wheat flour, sugar, yeast bicarbonate, salt and unsalted butter (fat) were purchased from a supermarket in Ilorin, Nigeria.

### 2.2 Methods

Preparation of Pawpaw Puree

The ripe pawpaw fruits were sorted, washed under running water, peeled manually with sharp stainless-steel knife, deseeded and sliced into thin slices. Thereafter, the thin slices were blended for 10 minutes to obtain the puree. The puree was packed in high density polyethylene (HDPE) bags and kept under refrigeration prior to use.

#### 2.2.1 Preparation of Crackers

The cracker production process in this study followed the recipe formulation outlined in Table 1. Margarine and ripe pawpaw puree, serving as the wet ingredients, were first mixed thoroughly to form a smooth batter. Separately, the dry ingredients consisting of wheat flour, baking powder, and sugar were combined before being incorporated into the batter. The resulting mixture was kneaded to form a uniform dough, which was then allowed to ferment for 1-3 h. After fermentation, the dough was rolled out to a uniform thickness of 2.5 mm, cut into square shapes using a hand-cutter, and lightly sprinkled with salt. Baking was carried out in an electric oven (fabricated by the Department of Food Engineering, University of Ilorin) at a temperature range of 130-170°C for 15 minutes. Once baked, the crackers were cooled to room temperature (25-30°C), packaged in plastic pouches, and stored for further analysis.

#### 2.2.2 Chemical analysis

Mineral contents (calcium, magnesium, sodium, potassium), vitamin C and proximate compositions (moisture, ash, protein, fibre and fat contents) of the produced crackers were estimated using the standard methods of the Association of Official Analytical Chemists (AOAC, 2005). Carbohydrate content was calculated by difference using equation 1. All analyses were done in duplicates and the results were expressed as an average value.

$$Carbohydrate\ (\%) = 100 - (\%Protein + \%Moisture + \%Fat + \%Ash + \%Fibre) \quad (1)$$

Table 1: Recipe for Crackers Production

| Ingredients | % Contribution |
|---|---|
| Wheat flour | 68 |
| Fat | 7 |
| Salt | 2 |
| Sugar | 2 |
| Yeast | 2 |
| Bicarbonate | 1 |
| Water | 17 |

#### 2.2.3 Experimental design and statistical analysis

Taguchi experimental design was used to investigate the effects of three processing parameters, baking temperature, fermentation duration, and fat-to-pawpaw puree ratio, on cracker development, resulting in nine experimental runs as presented in Table 2. The resulting data were analysed using one-way Analysis of Variance (ANOVA) to identify significant differences among the cracker samples using SPSS version 20.0. Descriptive statistics, including means and standard deviations, were calculated to summarize the results.

Table 2: Taguchi Experimental Design for the Production of Cracker

| Sample | Fat to Pawpaw Puree (%) | Fermentation Time (h) | Baking Temperature (°C) |
|---|---|---|---|
| 1 | 0 | 1 | 130 |
| 2 | 0 | 2 | 150 |
| 3 | 0 | 3 | 170 |
| 4 | 25 | 1 | 130 |
| 5 | 25 | 2 | 150 |
| 6 | 25 | 3 | 170 |
| 7 | 50 | 1 | 130 |
| 8 | 50 | 2 | 150 |
| 9 | 50 | 3 | 170 |

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate composition of crackers biscuit

The proximate composition of crackers produced by incorporating different percentage of ripe pawpaw puree and baked at different temperature and fermentation time is shown in Table 3. The lowest moisture contents observed in the produced crackers was 1.08% in sample 6 with 25% pawpaw puree incorporation, fermentation time of 3h and baking temperature of 170$^{o}$C while the highest was 4.28% in sample 7 with 50% pawpaw puree incorporation, fermentation time of 1h and baking temperature of 130$^{o}$C. These moisture contents are lower than 7.17-7.75% reported for chia seed crackers (Dundar et al., 2020), 7.43-9.19% for crackers made from cauliflower, wheat and rice flour (Sheikh et al., 2021), 4.94-6.56 % for crackers incorporated with pineapple peel powder (Mala et al., 2024) and 5.62-8.65% for crackers made from *Cucurbita moschata* and modified cassava flour (Indrianingsih et al., 2019).

Lower moisture contents (<5%) of baked crackers are an indication of quality as it helps to improve the shelf stability of the crackers. Therefore, the crackers produced in this study are shelf stable as the range of moisture contents observed is less than 5%. Similar findings were reported by Ng et al. (2020) for overripe banana pulp chocolate cookies and Uchegbu & Ishiwu (2015) for crackers made from blend of sprouted pigeon pea, unripe plantain and brewers' spent grain flour. The variation in the moisture content of the produced crackers may be attributed to the processing conditions used for the production.

The results of the ash contents of the cracker produced ranged between 2.11-2.31% in samples 4 and 7 respectively. It was observed that the sample incorporated with the highest percentage of pawpaw puree had the highest value of ash. This may be as a result of the fact that pawpaw is a rich source of mineral and high mineral content has been reported to increase ash content in food. It was also deduced from the study that the sample fermented for an hour had the highest and lowest ash contents, therefore fermentation period has little or no effect on the ash content of the crackers. The ash contents obtained from this study are higher than 0.72-1.23% and 0.71-1.23% reported by Ng et al. (2020) for overripe banana pulp chocolate cookies and Dundar et al. (2020) for crackers incorporated with chia seed respectively. Additionally, similar values (2.11, 2.41%) were obtained for some samples of crackers incorporated with pineapple peel powder (Mala et al., 2024).

The values obtained for fat content of the crackers produced ranged between 3.09 and 4.09% being the lowest and highest values respectively. These results are far lower than 13.31 mg/100g reported for whole wheat crackers fortified with tuna bone bio-calcium powder (Benjakul & Karnjanapratum, 2018), 14.22-14.92% for defatted coconut flour crackers (Mihiranie et al., 2017) and 12.83-17.26% for crackers made from acha and blanched pigeon pea blend (Olagunju et al., 2018). The lower fat contents obtained in this study made the crackers produced to be healthy snacks for varied categories of consumers especially people with certain health issues.

The results of this study also showed that incorporating pawpaw puree in cracker increased the crude protein contents of crackers as highest protein content of 12.51% was recorded in sample 8, which had 50% pawpaw puree concentration, and the lowest value (10.17%) was observed in sample 3 with 0% pawpaw puree concentration. It was also observed that fermentation duration and baking temperature had little effect on the protein content of the crackers. Protein values ranging from 16.8-43.0%, which is higher than those obtained in this study, were reported for crackers supplemented with pulse, starch and protein isolate (Gangola et al., 2022). However, similar results (11.8-12.66%) were reported in the findings of Mihiranie et al. (2017) for defatted coconut crackers.

The highest crude fibre was obtained in sample 4 with a value 1.66% at fermentation duration of 1 h, baking temperature of 130$^{o}$ C and 25% pawpaw puree incorporation while the lowest value of 1.19% was recorded in sample

2 at fermentation duration of 2 h, baking temperature of 150º C without pawpaw puree. With the addition of pawpaw puree, the fibre content of the cracker samples increased but at lower fermentation duration and baking temperature. These increase in crude fibre contents are in agreement with the findings of Mihiranie et al. (2017) for defatted coconut cracker, Maia et al. (2021) in the production of cookies made with legume flours and Wahab et al. (2018) for citrus peel powder substituted cake. Dietary fibre helps to prevent several diseases, reduces blood cholesterol level, slows down rate of absorption of glucose, and also plays important role in improving gut health (Gangola et al., 2022; Isik & Topkaya, 2016).

For carbohydrate contents of the cracker samples, sample 3 with 0% pawpaw puree, fermentation duration of 3 h and baking temperature of 170º C recorded the highest value of 82.11% while the lowest (75.47%) was recorded in sample 7 at fermentation duration of 1 h, baking temperature of 130ºC and incorporated with 50% pawpaw puree. The carbohydrate contents obtained were greater than the values reported for crackers supplemented with pulse, starch and protein isolate (Gangola et al., 2022), chocolate spread substituted with eggplant puree (Ali et al., 2020) and citrus peel powder cake (Wahab et al., 2018).

Table 3: Effects of baking parameters on proximate composition of crackers biscuit

| Sample | Moisture Content (%) | Ash Content (%) | Crude Fat (%) | Crude Protein (%) | Crude Fibre (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| 1 | 4.04±0.03$^{g}$ | 2.27±0.01$^{g}$ | 3.29±0.01$^{g}$ | 10.97±0.04$^{h}$ | 1.21±0.01$^{d}$ | 78.23±0.02$^{c}$ |
| 2 | 2.17±0.02$^{d}$ | 2.19±0.01$^{i}$ | 3.14±0.01$^{d}$ | 10.21±0.01$^{i}$ | 1.19±0.01$^{i}$ | 81.12±0.06$^{b}$ |
| 3 | 1.28±0.01$^{a}$ | 2.21±0.01$^{a}$ | 3.09±0.07$^{h}$ | 10.17±0.01$^{g}$ | 1.15±0.01$^{h}$ | 82.11±0.01$^{f}$ |
| 4 | 4.09±0.01$^{e}$ | 2.11±0.01$^{h}$ | 4.01±0.07$^{i}$ | 12.35±0.01$^{d}$ | 1.66±0.04$^{f}$ | 75.79±0.07$^{e}$ |
| 5 | 2.99±0.02$^{h}$ | 2.21±0.01$^{e}$ | 3.31±0.01$^{f}$ | 11.09±0.01$^{e}$ | 1.52±0.02$^{e}$ | 78.89±0.02$^{i}$ |
| 6 | 1.08±0.02$^{b}$ | 2.16±0.01$^{c}$ | 3.55±0.01$^{e}$ | 10.63±0.01$^{a}$ | 1.52±0.01$^{g}$ | 81.08±0.02$^{a}$ |
| 7 | 4.28±0.03$^{i}$ | 2.31±0.01$^{b}$ | 4.09±0.01$^{a}$ | 12.38±0.03$^{f}$ | 1.47±0.01$^{a}$ | 75.47±0.06$^{h}$ |
| 8 | 2.86±0.04$^{c}$ | 2.25±0.01$^{f}$ | 3.83±0.01$^{b}$ | 12.51±0.01$^{b}$ | 1.52±0.01$^{b}$ | 77.05±0.04$^{d}$ |
| 9 | 1.35±0.01$^{f}$ | 2.29±0.01$^{d}$ | 3.65±0.01$^{c}$ | 12.47±0.01$^{c}$ | 1.52±0.01$^{c}$ | 78.72±0.04$^{g}$ |

Samples with different superscripts within same column are significantly different ($p \leq 0.05$)

3.2 Effects of Baking Parameters on Mineral Contents of the Crackers

The results of the effects of baking parameters on some mineral elements (calcium, magnesium, sodium and potassium) of the crackers are presented in Figure 1. The range of values obtained for these minerals are calcium (180-241 mg/100 g), magnesium (24.90-36.82 mg/100 g), sodium (423.1-488.2 mg/100 g) and potassium (122.8-220.8 mg/100 g). It was observed from the study that the addition of pawpaw puree to replace some of the fats had effects on the minerals evaluated. It was also deduced from the results that samples with 50% pawpaw puree had higher values for calcium, sodium and potassium. However, magnesium contents of the cracker samples recorded lower values when compared to other mineral elements analysed.

Minerals play significant roles in various metabolic processes relevant to humans' survival thus; incorporating pawpaw puree in the produced crackers has greatly improved the mineral contents necessary for optimal health. Similar trends were reported in the findings of Sheikh et al. (2021) for wheat and rice crackers incorporated with cauliflowers; Ogo et al. (2021) for novel biscuits made from wheat supplemented with watermelon rinds and orange pomace flour blends and Roni et al. (2021) for cake fortified with moringa oleifera leaf powder and ripe banana flour.

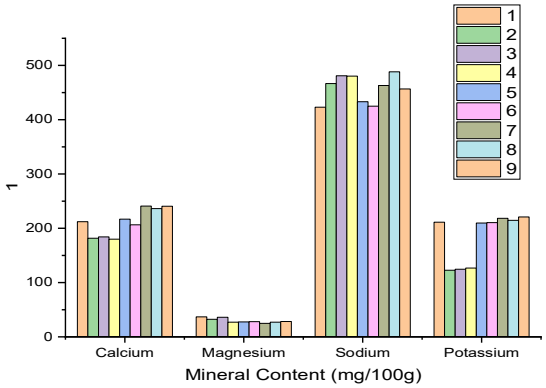



Figure 1: Effect of Baking Parameters on Mineral Contents of the Crackers

3.3 Effects of Baking Parameters on Vitamin C Composition of the Crackers

Vitamin C (also referred to as ascorbic acid) is one of the essential vitamins require for proper growth and development of the body. It is very important in human diet as it helps tissues repair, collagen formation and many other body building functions (Murtala et al., 2016). The vitamin C contents of cracker samples obtained ranges from 9.18-16.32 mg/100 g and are presented in Figure 2. Sample 8 with 50% pawpaw puree concentration, baking temperature of 150ºC and fermentation duration of 2 h had the highest value of ascorbic acid while sample 3 with 0% pawpaw puree concentration, baking temperature of 170ºC and fermentation duration of 3 h recorded the lowest vitamin C content. By critically observing the increase in the vitamin C trend in this study, it can be deduced that increase in pawpaw puree concentration led to a corresponding increase in the vitamin C content in the crackers produced. This could be traced to the high concentration of vitamin C present in pawpaw fruit (Zerihun & Minuye, 2020). The fermentation duration and baking temperature does not have much effect as compared with pawpaw puree concentration. These values are higher than those reported by (Kure et al., 2021) pawpaw seed incorporated wheat bread but lower than the values recorded for biscuit produced from wheat-cocoyam composite flour (Makanjuola & Adebowale, 2020).

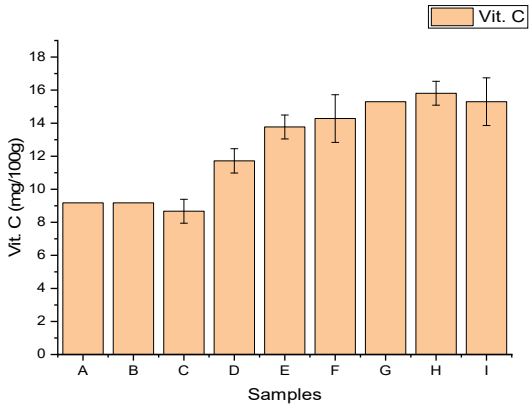



Figure 2: The effect of baking parameters on vitamin C of the crackers

## 4. CONCLUSION

Cracker biscuit was produced by using pawpaw puree as a fat substitute. The cracker biscuit containing 50% pawpaw puree concentration was the most accepted when compared with other formulated cracker biscuits containing no pawpaw puree. The use of 25% and 50% of pawpaw puree to margarine at 1 h fermentation duration increases the ash, fat, fibre, calcium and magnesium. Substitution of pawpaw puree into the cracker biscuit increased the proximate composition, sodium and potassium except carbohydrate. It can be concluded that the incorporation of pawpaw puree, fermentation duration and baking temperature has significant effect on the proximate composition, vitamin C and mineral content of the cracker biscuit samples and this may assist in diversifying the use of pawpaw puree on food products.

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