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Effects of Frying time and Layering of Moringa (*Moringa stenopetala*) Leaf Powder on Oxidative Stability and Total Carotenoids of Banana Chips

Mesfin Wolde

wcritical121@gmail.com

Southwest Ethiopia Agricultural Research Institute https://orcid.org/0009-0005-2240-2136

Abadi Gebre

Hawassa University https://orcid.org/0000-0002-9269-6011

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Abstract

Banana (Musa-sapientum L) is a typical climacteric fruit that highly cultivated and mostly accepted fruit due to its sensorial acceptability and nutritional value. It is known for its short-shelf stability and developing a shelf stable banana product is essential. The aim of this study was to determine the effects of frying time and layering of Moringa leaf powder on free fatty acid, peroxide value and total carotenoids on banana chips. In this study the two levels of moringa leaf powder layering (3% & 6%) and three levels of frying time (1.5, 2, & 2.5 minutes) were combined. The results showed that the banana chips had free fatty acid (0.19g/100g–1.19g/100g), per oxide value (0.78g/100g–1.79g/100g) and total carotenoid contents (50.59µg /g- 373.10 µg /g). The FFA and PV of banana chips were negatively affected by concentration of moringa leaf powder. On the other hand, the fat content of banana chips resulted higher through frying time due to the replacement of moisture with frying oil. The increased concentration of moringa leaf powder somehow reduces the losses of total carotenoids. The layering of moringa leaf powder during prolonged frying to banana chips improves oxidative stabilities without compromising the total carotenoid contents of banana chips

INTRODUCTION

In Ethiopia, dessert banana is the major fruit crop that is most widely grown and consumed. It grows in several parts where the growing conditions are conducive. In Ethiopia, the Southern Nations Nationalities and Peoples' Regional State is one of the major production areas for banana (CSA, 2014). Gamo-Gofa, Bench-Maji and Sheka zones are among the major banana producing zones of the SNNPRS, of which Gamo-Gofa zone alone covers over 70% of the total banana marketed across the major market outlets in Ethiopia (CFC, 2004). Currently, there is very limited commercial processing of bananas. Most people consume bananas fresh, steamed or boiled. During bumper harvests, farmers sell bananas at giveaway prices and many go to waste. Processing of banana to chips may add value to this fruit and reduce the wasted banana (Abd *et al*., 2014).

Frying is one of the most common processing techniques to make banana chips (Wani et al., 2017). Deep-frying is an established process of banana chips preparation. In study reported by Wani et al., (2017) chips thickness, frying time and frying temperature affected the banana chips quality in deep fat frying. Banana chips have been found to be inferior in protein quality and oxidative stability. It was reported that addition of moringa leaves could improve protein level and anti-oxidative properties of smoothies (in moringa powder based banana beverages) (Taiwo, 2018). However, there is limited study towards the influences addition of moringa stenopetala leaf powder and frying times on nutritional quality, oxidative stability and sensory properties of banana chips with particular focus on banana from Ethiopia. Thus, the aim of this study is to evaluate the analysis of nutritional characteristics of banana chips as influenced by frying condition

MATERIAL AND METHODS

Materials

Sample Collection

Samples (banana, moringa and oil) were collected and secured based on their requirement. Green mature banana (*Musasaptieum*) was collected from Southern Agricultural Research Institute and while moringa stenopetala leaf was received from Arbaminch Agricultural Research Center. Edible oil was purchased from local market, Hawassa, Ethiopia. Banana (*Musasapitium*) samples with similar mass, maturity, and ripening stage was selected and used for the experiment.

Sample Preparations

Moringa stenopetala leaf powder was prepared by distributing leaflets thinly on mash tied on racks in well ventilated room. The leaves were dried within a maximum of 4 days in a loading density of 1 kg/m^2. The dried leaf was milled by mortar the final product was sieved by (0.2 mm) screen size to obtain very fine powder (Sauveur & Bronin, 2006). According to wani et al., (2017) the cleaned green banana was peeled, washed with soft water at room temperature and then cut into slices 2 mm thick each weighing approximately 1 gram. The slice was immersed in to 2% salt solution to prevent enzymatic browning. All slices were reshaped to the same circular pieces diameter of 4 cm and moringa powder was layered on banana slice. The technique carried out by measuring the weight of slice and 3 and 6% of moringa stenopetala leaf powder. Half of moringa stenopetala leaf powder was uniformly distributed on the circular pieces and the layer was on both sides of the slice; then the slices was dried in an oven dryer at 65°C for 30 minutes.

Frying

The prepared and dried banana slices were deep fried at a temperature of 180ºC in vegetable oil according to (Wanakamol &Poonlarp, 2018) all fried chips were drained for 15 seconds to remove excess oil. Then the fried chips were packed in polyethylene bags and stored in cold place without sunlight until analysis.

Treatments and Experimental Design

The experiment was designed as a full factorial experiment in which the treatments consider all possible combinations of the selected levels. In these experiment two factors (frying time and layering of moringa leaf powder) were considered.

Free fatty acid determination

Free fatty acid content, or acid value, reflects the amount of fatty acids hydrolyzed from triacylglycerol's. A banana chips (5 g) was weighed into a 250- ml Erlenmeyer flask and 100 ml neutralized ethanol was mixed and 2 ml phenolphthalein was used as indicator and shacked to dissolve the mixture completely. Then the mixture was titrated with standard base (ca. 0.1 N NaOH), and shaken vigorously until the endpoint was reached indicated by a slight pink color that persists for 30 second. The FFA value of each sample was calculated according to IUPAC, (1987).

Peroxide value determination

Peroxide value (mill equivalents oxygen per kg fat) was determined based upon subjecting potassium iodide at room temperature to the oxidant effect of peroxides. The iodine thus liberated was titrated with sodium thiosulphate as described by (IUPAC, 1987). Approximately 1g of the chips sample was weighed into a 100 mL conical flask and dissolved in with 10 mL of the solvent (3/2 mixture glacial acetic acid/chloroform (V/V). Subsequently, 0.2 mL of the potassium iodide saturated solution (14 g KI in 10 mL distilled water) was added to the mixture and allowed to stand in the dark for exactly 1 minute. Using 20 mL of 1% starch solution as indicator, the mixture was titrated with 0.01 N sodium thiosulphate solutions (color: purple › colorless). Simultaneously, blank test was carried out without fat under the same conditions.

Total carotenoids determinations

The total carotenoid content extraction was carried out according to Imungi and Wabule (1990).

Beta carotene content was determined spectrophotometric ally as described by Muchoki et al. (2007).

Statistical Analysis

Data analyzed using factorial ANOVA and the means were separated using Tukey's HSD test at $p < 0.05$. Principal Component Analysis (PCA) for all numerical results was performed using XLSTAT version 2016.03.30882 (Addinsoft, New York).

RESULTS AND DISCUSSION

Effect of Frying time and layering of Moringa leaf powder on Free Fatty Acid and Peroxide value of banana chips

Free fatty acids and Peroxide value are essential quality parameters of frying oil and fried products. Free fatty acids are derived from triacylglycerol by cleavage of ester bonds due to the action of lipase, high temperature, and/or moisture. Thus, high free fatty acids content in the frying oil may cause further oxidation and lead to development of offensive taste and flavor. Free fatty acids content is one of the most important concerns in the refining of edible oil and also in the frying of foods. It is often used to

indicate oil quality and its suitability for edibility (Chew & Nyam, 2020). The Peroxide Value is a parameter specifying the content of oxygen as peroxide, especially hydroperoxides in a substance. The Peroxide Value is a measure of the oxidation present. Peroxide values are expressed either in mill equivalents of peroxide/kg or in mill moles of peroxide/L. Thus, the free fatty acids and peroxide value of the fried banana chips were analyzed (Table 1).

Table 1
Effect of frying time and layering of moringa leaf powder on free fatty acid and peroxide value of banana chips

Frying time (min)	**MLP (%)**	**FFA(g/100g)**	**PV(g/100g)**
1.5	0	$0.28 \pm .03^{a}$	$1.47\pm.05^{d}$
	3	$0.25\pm.04^{a}$	$1.14\pm.04^{a}$
	6	$0.19\pm.02^{a}$	$0.78\pm.04^{b}$
2.5	0	$0.98\pm.10^{d}$	$1.79\pm.07^{e}$
	3	$0.55\pm.07^{bc}$	$1.17\pm.02^{a}$
	6	$0.46\pm.03^{b}$	$0.92\pm.01^{c}$
REF		$0.67\pm.03^{c}$	$1.63\pm.04^{f}$

Values are mean ± SD of triplicate determinations. Mean values with different superscripts down the column are significantly different ($p < 0.05$). REF (local chips), LSD = Least Significant Difference

Free fatty acids level of fried banana chips varied from 0.19 to 0.98 g/100g (Table 1). Banana chips fried without moringa leaf powder for 2.5 minutes had highest level of free fatty acids. While, banana chips fried with 6% of moringa leaf powder for 1.5 minutes had lowest free fatty acids. The banana chips fried without moringa leaf powder, with 3% and 6% moringa leaf powder for 1.5 minutes had similar free fatty acids level. However, free fatty acids of the banana chips decreased linearly with increased concentration of moringa leaf powder from 3 to 6%. On the other hand, frying time had significantly increased the free fatty acids content of the banana chips ($p < 0.05$), due to hydrolysis or cleavage and oxidation of fatty acid double bonds (Aida *et al*., 2016). It is evident that the layering of moringa leaf powder at all levels decreased the formation of free fatty acids with frying time. This study is consistent with (Fereidoon, 2005) that reported the addition of moringa leaf powder reduced the free fatty acids level of fried products due to the presence of natural antioxidants in the leaves of morigna.

The peroxide value of fried banana chips ranged from 0.79 to 1.79 g/100g (Table 1). The highest peroxide value was recorded for banana chips fried without moringa leaf powder for 2.5 minutes. While, the lowest peroxide value was recorded for Banana chips fried with 6% moringa leaf powder for 1.5 minutes. Peroxide values of banana chips fried with 3% moringa leaf powder for 1.5 minutes and 2.5 minutes had similar peroxide value. However, all treatments had lower ($p < 0.05$) peroxide value

compared to the reference. The peroxide value of the fried banana chips increased with increasing frying duration and decreased with increased in concentration of moringa leaf powder. This result is an indicative of successful and efficient inhibition of oxidation process and improved keeping quality by moringa leaf powder layering. Furthermore, the peroxide value of the banana chips is a sign of oxidation which directly translates to the buildup and breakdown of oxidation products (Omara and Erisa, 2019).

Effect of frying time and layering of moringa leaf powder on total carotenoids of banana chips

The total carotenoids level of fried banana chips ranged considerably between 50.59 and 373.10 µg/g (Table 2). The total carotenoids content of banana chips fried without moringa leaf powder for 2.5 minutes and reference sample was not significantly different ($p < 0.05$). An increased concentration of moringa leaf powder from 3 to 6% increased the total carotenoids content. This is due ant oxidative properties of mooring (Nadeem *et al*., 2013). Furthermore, banana chips prepared with different frying times had also significantly different total carotenoids. This study was supported by the reports of (Demasse *et al*., 2006) about the total carotenoids and vitamin C losses during frying that were linked to the behavior of physicochemical parameters during the water/lipids exchange.

Table 2
Effect of frying time and layering of moringa stenopetala leaf powder on total carotenoids of banana chips.

Frying time (min)	MLP (%)	Total carotenoids (µg /g)
1.5	0	148.39 ± 3.55^{d}
	3	313.44 ± 4.86^{e}
	6	373.10 ± 4.53^{f}
2.5	0	$50.59 \pm 0.83ab^{e}$
	3	54.52 ± 1.53^{a}
	6	112.28 ± 3.22^{c}
REF		81.72 ± 2.43^{b}

Values are mean ± SD of triplicates determinations. Mean values with different superscripts down the column are significantly different ($p < 0.05$). Where REF (local chips), LSD = Least Significant Difference

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was conducted to confirm association of frying time and moringa leaf powder addition with the presumed banana chips quality (free fatty acids, peroxide value and total carotenoids). Principal Component Analysis showed that the banana chips fried with higher level of

moringa leaf powder (BC3 and BC6) were aligned together with (total carotenoids) (Fig. 1). These banana chips were on the same PC1 quadrant as total carotenoids. It also indicated that the banana chips that was fried from only banana BC1, BC4 and reference sample (locally processed chips) were negatively associated with total carotenoids. The banana chips fried without moringa leaf powder for 1.5 minutes (BC1) and banana fried with 3% moringa leaf powder for 1.5 minutes (BC2) were aligned together with peroxide value. Moreover, PCA indicated that the banana chips fried without moringa leaf powder, reference (locally processed chips) (REF), and BC1 and BC2 were associated with higher peroxide value. However, moringa leaf powder layered banana chips was associated with increased total carotenoids and decreased peroxide values resulting in the opposite to the PC3 quadrant.

Banana chips

BC1 (only banana for 1.5min), BC2 (banana with 3% moringa leaf powder for 1.5min), BC3 (banana with 6% moringa leaf powder for 1.5min), BC4 (only banana for 2.5min) BC5 (banana with 3% moringa leaf powder for 2.5min), BC6(banana with 6% moringa leaf powder for 2.5min), REF(local chips)

Principal Component analysis loading

(free fatty acid value, peroxide value, and total carotenoids)

CONCLUSION AND RECOMMENDATIONS

The amount of total carotenoids content of banana chips negatively affected by frying time. The increased concentration of moringa leaf powder somehow reduces the losses of total carotenoids. While, the total carotenoids content of banana chips fried with 6% of moringa leaf powder for 2.5 minutes and reference sample (locally processed chips) were similar. Finally, layering of 6% MLP improved quality of banana chips intermes of oxidative property and total caroteinoids. However, future research could complement with other chips quality parameters that includemicrobiological analysis, minerals, amino acid profiling, other anti-oxidative stability indicators (DPPH scavenging activity, ferric reducing assay power and total antioxidant activity) and cost benefit analysis of moringa leaf powder based banana chips.

Declarations

Conflicts of interest

The author declared that he has no conflict of interest

Author contributions

Mr. Mesfin Wolde performed the study design, practical work and writing of the final manuscript. He was also being the corresponding author for the article in publication. Dr Abadi Gebre Mezgebe (Associate Professor of food science and technology at Hawassa University) participated in reviewing, supervising, data validation, advice and technical direction throughout the process.

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Figures

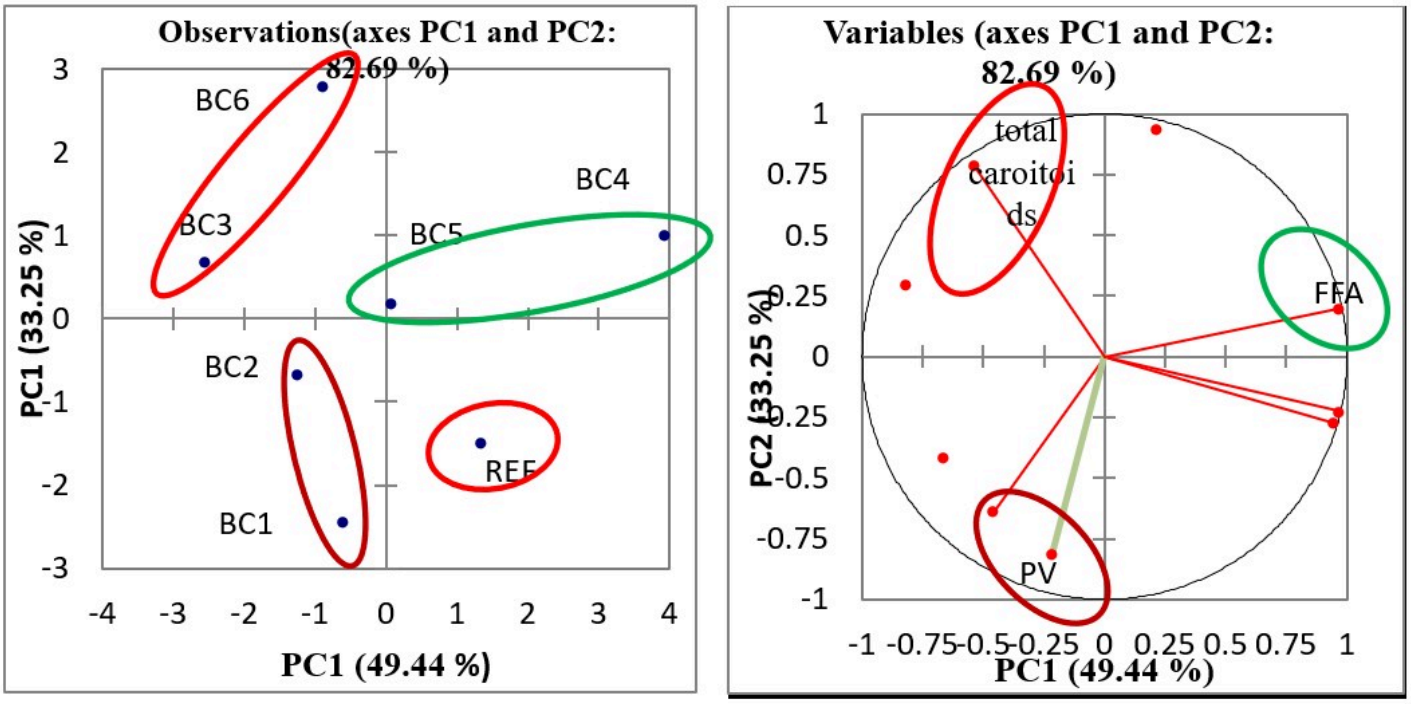


Figure 1

Principal Component analysis of chemical composition and oxidative stability of banana chips fried at different time and layering of moringa leaf powder.