IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 14, Issue 12 Ser. II (December 2020), PP 31-36
www.iosrjournals.org

Evaluation of nutritional, physicochemical and sensory properties of vacuum dehydrated *seeni* banana (*Musa acuminata ABB*) snacks

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Abstract:
Background: *Seeni banana (Musa acuminata ABB) is a highly nutritious fruit which has high postharvest loss compared to other banana varieties, due to the high perishability and inadequate preservation methods in Developing countries. Society is already consuming banana snacks which are deep fried of high fat content with the concerns and knowledge of non-communicable diseases such as Cardio Vascular Diseases, Cancers.*
Materials and Methods: *This study was focused on extending the shelf life of Seeni Banana (Musa acuminata ABB) by dehydrating the eighty percent ripen fresh banana in to a snack by making use of vacuum dehydration. The final product was evaluated for microbiological properties (Total viable plate count, Yeast and mold count, Escherichia coli) prior to the sensory evaluations at three different phases during storage of two months. Proximate analysis of the snack sample was conducted according to the standard methods of AOAC (2000).*
Results*: Developed snack sample consist of 1.08 ± 0.00% moisture, 2.39 ± 0.005% crude fiber, 0.90 ± 0.01% free fat, 14.55 ± 0.04% protein, and 3.1 ± 0.00% ash according to the AOAC standard proximate analysis methods. 20.77 % yield could be obtained after dehydration. Evaluation of microbiological properties ensured that, the product is within the International limits stipulated by World Health Organization. Antioxidant activity of the snack has been significantly reduced, while moisture content has been significantly increased (P < 0.05) over two month's storage. Based on sensory panelists' evaluation color, aroma, taste, mouth feel, texture and overall acceptability of developed snacks was not affected by storage time.*
Conclusion: *Therefore, production of vacuum dehydrated seeni banana snacks will retain, condense the nutritional value as in fresh seeni banana, also it will enhance the shelf life of seeni banana. Dehydrated snack will be a best alternative for deep fried banana snacks due to its low free fat content, based on the proximate analysis results.*
Key Word*: Dehydrated banana, proximate analysis, sensory evaluation, snacks, vacuum dehydration*

Date of Submission: 14-12-2020 Date of Acceptance: 28-12-2020

I. Introduction

Seeni Banana (*Musa acuminata ABB)* is an alternative perennial fruit crop for farmers due to its availability throughout the year. In Sri Lanka, it can be considered as a major staple fruit crop. It is one of the abundant cultivated varieties in Sri Lanka[16].Although they have high nutritional value (vitamin B6, soluble fiber, resistant starch, moderate amounts of vitamins C which have high antioxidant activity and potassium) which cannot gain easily from any other fruit or vegetable[5]. A large quantity of unmarketable surplus is available in the banana growing areas and very few processed products are marketed in Sri Lanka[11]. As they are low in fat, cholesterol and salt, a great potential exists for banana value added products due to its limited preservation methods and its proven health benefits. This study was focused on extending the shelf life of Seeni Banana (*Musa acuminata ABB*) by dehydrating the fresh banana in to a healthy snack by making use of vacuum dehydration[4]. High shelf life coupled with adequate processing facilities results in heavy revenue to the country by exportation. Development of snacks using most abundant banana varieties in Sri Lanka with appropriate dehydration techniques to produce healthier, shelf stable and convenience are the prime requirements that achieved by this study for the present competitive markets[8]. Microbial properties and the sensory quality attributes of the developed final product was tested in order to evaluate the shelf life. Proximate analysis was carried out for final product with the objective of evaluating the difference in fat content, moisture contents of the snack before dehydration and after dehydration.

II. Material and Methods

This research was conducted at the food science laboratory in Food Research Unit at Gannoruwa, Peradeniya, Sri Lanka from August, 2018 to December, 2018.

Study Location: Food Science Laboratory in Food Research Unit at Gannoruwa, Peradeniya, Sri Lanka

Study Duration: August, 2018 to December, 2018.

Procedure methodology

Eighty percent ripen fresh banana (variety *Seeni)* were purchased from a commercial farm. Diseased and damaged fruits were discarded to minimize biological variability. Ripen (more yellow than green) banana fruits (*seeni* variety) were well cleaned with clean water to remove dirt, dust and pesticide residues (if any). The stem scars were removed from the fruits. Physical parameters of fresh banana like fruit weight, maximum and minimum diameter of fruit with peel, length, skin thickness, puncture operation was recorded prior to snack preparation. Cleaned bananas were peeled off & sliced crosswise with 7 mm uniform thickness and sliced bananas were dipped in 0.3% citric acid solution for 30 seconds. Slices were steam blanched for 1 minute to avoid enzymatic browning, to reduce development of undesirable off flavors, off colors. Processed banana were allowed to dehydrate with vacuum dehydration (45°C). Those dehydrated banana snacks were packed with HDPP/ High Density Polypropylene (300 gauge) and labelled as Vacuum dehydrated *Seeni* banana snacks,

Proximate Analysis: Moisture, total ash, crude protein, crude fiber, free fat content of the dehydrated snacks was determined in triplicates according to the standard methods of AOAC (2000)[3].

Physicochemical, phytochemical, Microbial and Sensory properties of newly developed snacks samples were evaluated at 3 phases of storage. (Just after dehydration, Storage study after 1 month, Storage study after 2 months). Physicochemical properties such as firmness, color was measured using hand held effegi penetrometer, standard color chart respectively. Ascorbic acid content was measured using AOAC 967.21, 2000 referenced method[3]. Phytochemical properties like total phenolic content, antioxidant activity throughout the storage period was measured with Singleton method, 1999 [18] and Kriengsak T. *et al.,* 2006 referenced method [10].

Microbiological analysis was done prior to each sensory evaluation in order to ensure that final product is safe for human consumption throughout the storage. Total Plate count, Yeast and mold count and enumeration of *E. Coli* in the snacks were evaluated using the methods of SLS: 516 part 1 (1991).

Developed snack samples were tested for color, aroma, taste, mouth-feel, texture, overall acceptability by using 25 trained sensory panelists and 9- point hedonic scale.

Statistical analysis

Statistical data analysis was done with Minitab 16 Statistical software. Sensory evaluation data were analyzed with Kruskal Wallis non parametric statistical method which regards to color, aroma, taste, mouth feel, texture, overall acceptability. Physicochemical properties, phytochemical properties and proximate analysis of the final product was analyzed with one-way ANOVA at 95% significance level and Tukey's test ($p \leq 0.05$) to for mean comparison.

III. Result

Microbiological Quality

There are no any indicator organisms of food contamination like *Escherichia. coli.* Therefore, final product is acceptable for the human consumption until 2 months storage according to the results shown in table 1 where the mean total viable plate counts and mean yeast and mold counts were not detected during microbiological property evaluation.

Table 1: Microbiological results of dehydrated snacks during storage of two months

Storage time	Mean total viable plate count	Mean yeast and mold count
Initial snacks	Nil	Nil
After 1 month	Nil	Nil
After 2 months	Nil	Nil

Proximate analysis

Data on table no. 2 confirms that processing of Seeni banana into dehydrated banana snacks is effective which regards to nutritional value as it is having the basic nutrients in required amounts and its nutrients have concentrated with dehydration when compared to fresh *seeni* banana. Moisture content have evaporated and nearly 1.08% of moisture remained in the dehydrated banana snack and crude fiber content also have reduced significantly while other proximate constituents have concentrated with the removal of moisture.

Table 2: Proximate analysis comparison of fresh seeni banana and snack samples

Proximate constituent	Fresh *seeni* banana	Dehydrated Snacks
Moisture %	66.49 ± 0.00	1.08 ± 0.00
Crude fiber%	3.1 ± 0.00	2.39 ± 0.005
Fat %	0.05 ± 0.00	0.90 ± 0.01
Protein %	1.51 ± 0.00	14.55 ± 0.04
Ash %	0.8 ± 0.00	3.1 ± 0.00
Carbohydrate%	31.13 ± 0.00	77.9 ± 0.04

Proximate Composition of the Fresh Seeni Banana; Source: "Composition of foods'' by Gebhardt S.E *et al.*,1982, United states Department of Agriculture, Agricultural Handbook, no.8, p.60, Washington D.C, United States Government printing office.

Physicochemical and phytochemical results of the final product

Table 3: Comparison of physicochemical, phytochemical properties of snack with storage

Storage time	Color	Total Phenolic content (mg GAE 100 g^{-1})	Mean Antioxidant activity / IC50 (mg ml^{-1})
Initial (0)	GOG-163 D	$572.34^{a} \pm 1.1$	$256.91^{c} \pm 1.1$
1st month (30)	YG-10 CD	$551.7^{a} \pm 0.7$,	$522.61^{b} \pm 2.45$
2nd month (60)	YOG-16 CD	$457.8^{b} \pm 0.98$	$971.1^{a} \pm 1.59$

Values are means of triplicates ± Standard error
Means with the same letters in same column are not significantly different from each other

As in the table 3, the color of the snacks has changed over storage period. Significant change in the Total phenolic compounds can be observed after the 1st month of storage where the values are $551.7^{a} \pm 0.7$ mg GAE 100 g^{-1} and, $457.8^{b} \pm 0.98$ mg GAE 100 g^{-1}. However no significant change in the Total Phenolic content in between initial snacks and at the first month storage study where the values are $572.34^{a} \pm 1.1$ mg GAE 100 g^{-1} and $551.7^{a} \pm 0.7$ mg GAE 100 g^{-1}. Oxidation of total polyphenolic compounds, antioxidants lead to significant reduction in antioxidant activity /increasing IC 50 value with the storage of two months from $256.91^{c} \pm 1.1$ (mg ml^{-1}), $522.61^{b} \pm 2.45$ (mg ml^{-1}), $971.1^{a} \pm 1.59$ (mg ml^{-1}).

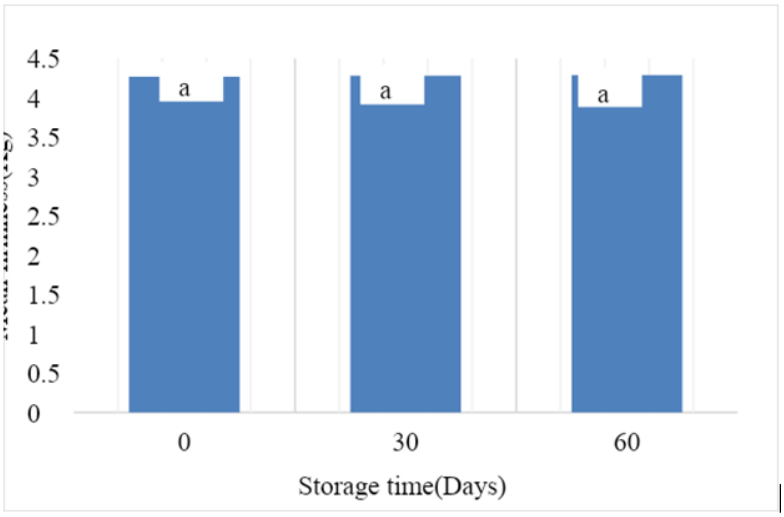

Figure 1. Changes of mean firmness during storage

Mean firmness of the dehydrated banana snack samples did not significantly changed with the storage time as shown in the fig. no 1 which is very crucial for snacks as the firmness will affect on the texture and the mouthfeel which are considered to be important sensory parameters.

Sensory evaluation of the developed products

Table 4: Kruskal-Wallis test results for sensory attributes of the snack during storage

Sensory attribute	Vacuum dehydrated *seeni* banana snacks			
	Initial	1 month	2 months	P value
Color	8.00	8.00	8.00	0.076
Aroma	6.00	6.00	6.00	0.866
Taste	8.00	8.00	8.00	0.850
Mouth feel	8.00	7.00	8.00	0.495
Texture	8.00	8.00	8.00	0.538
Overall Acceptability	8.00	8.00	8.00	0.458

Table 4 shows the P values for color: 0.076, for aroma :0.866, for taste: 0.850, for mouthfeel: 0.495, for texture: 0.538, for overall acceptability: 0.458 where all the p values are greater than 0.05 according to the Kruskal- Wallis non parametric test results. Therefore, there is no any significant change of sensory attributes with the storage time. However, the mean test value of mouthfeel has been reduced (from 8.00 to 7.00) and then again increased (7.00 to8.00) during storage.

Below illustrated figure 2 with the web diagram of the sensory data for the shelf-life evaluation showed that there is no any significant difference in color, aroma, taste, mouth feel, texture, overall acceptability of snacks during storage of 2 months.

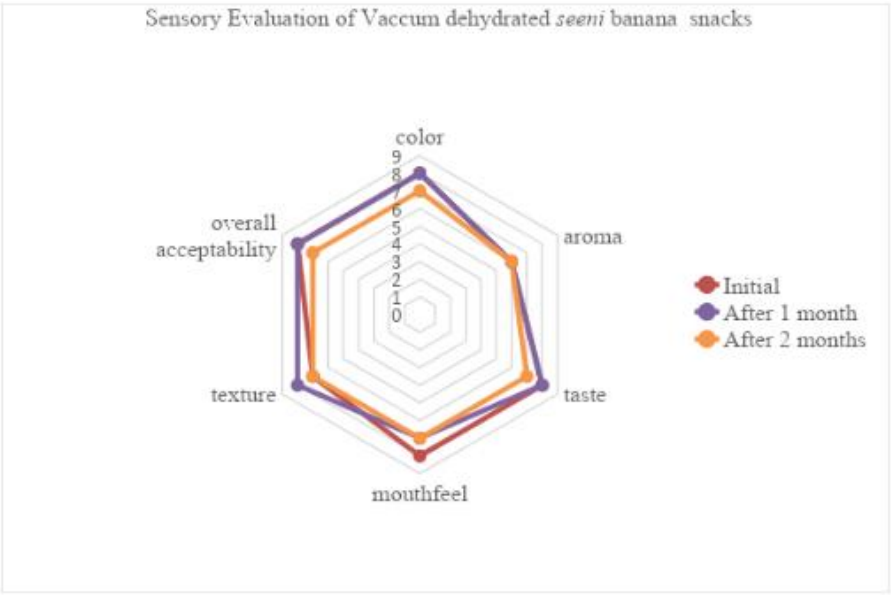

Figure 2: Web diagram of the sensory properties of snack for the shelf-life evaluation

IV. Discussion

As this *seeni* banana snack was dehydrated, low moisture content of a food product led to least microbial hazards. Yeast and mold counts are related with sugar-based fruits with high moisture content, but as final product is having low moisture content, fungi were not observed. Microbial counts and pathogens lower than international stipulated limits by WHO (10^3 CFU g^{-1} for fungi and 10^1 CFU g^{-1} for bacteria) in both commercially and conventionally produced dehydrated fruits and vegetables are safe to consume for the human without any disabilities or poisoning after consumption[14]. There was no any mean plate count observed for banana snack samples during storage of 2 months. Thus far, bacteria had not grown in these snacks, as bacteria find conditions of low pH of the dehydrated snacks. There is no any indicator organisms of food contamination like *E. coli*. Therefore, final product is acceptable for the human consumption until 2 months storage according to the results shown in table no.1.

Food moisture analysis involves the whole coverage of the food items in the world because foods are comprising a considerable amount of water rather than other ingredients. When the snack was produced with dehydration, a considerable amount of moisture was evaporated due to high temperature of 55º C and only 1.08 ± 0.00 % moisture content was remained. Moisture content of the food material is important to consider the food is suitable before the consumption, because moisture content affects the physical, chemical aspects of food which relates with the freshness and stability for the storage of the food for a long period of time and the

moisture content determine the actual quality of the food before consumption and to the subsequent processing in the food sector by the food producers [2.]

According to OffiaOlua and Ekwunife (2015), High values of ash content show high mineral constituents. There is also considerable amount of crude fiber 2.39 ± 0.005% which have the potential to promote human gut health [15]. Dietary fibre in a food product is said to be beneficial as it shows a lower risk of developing coronary heart diseases, hypertension, diabetes, obesity, certain gastrointestinal diseases and colorectal cancers of human. Above data on table 1 confirms that processing of Seeni banana into dehydrated banana snacks is effective which regards to nutritional value as it is having the basic nutrients in required amounts and its nutrients have concentrated with dehydration when compared to fresh *seeni* banana. Usually, fried chips are produced from under ripe bananas, of which slices are deep-fried in palm oil or coconut oil, which are dry. If ripe bananas are used, they come out oily [2.] In this research, the banana snacks were dehydrated instead of frying or deep frying. Because of that, the fat content is very low (0.90 ± 0.01 %) with in the dehydrated snack compared with the fat content of deep fried or fried banana (31.9 ± 0.50 %) observed from previous literature [2,6]. The recent studies have found that fried foods or deep fried foods contain higher fat content of (>35%) which have the potential to cause Non-Communicable Diseases (NCDs) such as Diabetes (23.6%), HBP (37.9%), Obesity (16.0%) o Overweight (34.9%), High cholesterol (34.7%) (NCD, 2015 – Mauritian population aged 25-74 years) [13].

As a food product is getting fried, the internal cells become dehydrated and the evaporated water is partially replaced by the frying oil. Besides that, Saguy and Pinthus (1995) suggested that as the water is evaporated from the food product during frying, the rate of oil absorption increases due to a reduction in the pore internal pressure. But In this research, instead of frying or deep frying as vacuum dehydration was utilized for the banana snack production, the health concerns of consumers which related to high fat intake could be relieved.

Vacuum dehydrated *Seeni* banana snack samples had similar color compared to fresh banana. Prolong High temperatures also increase the tendency to turn brown [6]. As there is no prolonged temperature increase during vacuum dehydration, like in cabinet dehydration the color similar to the fresh banana is giving the competitive advantage over cabinet dehydrated snacks. As in the table 3, the color of the snacks has changed over storage period.

Vacuum dehydrated *Seeni* banana snack samples had similar color compared to fresh banana. Prolong High temperatures also increase the tendency to turn brown [6.] As there is no prolonged temperature increase during vacuum dehydration, like in cabinet dehydration the color similar to the fresh banana is giving the competitive advantage over cabinet dehydrated snacks. According to Fleuriet *et al.*, 1990, there were different types of antioxidants and studied total phenolic and tannin contents in banana pulp [6]. However, the content of another flavonoid, catechin, in bananas has not yet been studied. However, the total phenolic content reduction may be due to the total polyphenolic oxidation caused due to prolong heat during dehydration. The total phenolic compounds significantly reduced with the time as in the table no. 3, due to oxidation with the polyphenolic oxidase enzyme which tally with the antioxidant activity results. It is well known that bananas contain various antioxidants, such as vitamin C, vitamin E, flavonoids and β carotene [1,9,16]. The antioxidant capacity represents the ability to inhibit the process of oxidation [12].

Ascorbic acid is highly sensitive to light, heat, oxygen which accelerates oxidation of ascorbic acid. But here, mean ascorbic acid content significantly changed with the time 11.32^{a} ± 0.02, 11.3^{a} ± 0.2, 10.71^{b} ± 0.025 snacks. It's because of the lower temperatures during vacuum dehydration which ensures that there is no prolong heating. So low temperatures arrest oxidation of ascorbic acid.

There is no any significant difference in mean firmness as shown in the above figure 1, where the crispiness of snacks won't change. Therefore, it is favorable for the storage where shelf life has ensured without the soggy condition. Firmness could increase due to staling which is the process resulting physicochemical changes, change in flavor of food during storage. If above alterations occur, the food quality gradually deteriorates and loses its freshness, which results in an increase in firmness and rigidity. If there was increment in firmness, eventually it will lead to a reduction in the consumer acceptability, which attributed to the reduction in the eating quality of snacks [19]. As there is no any increment in firmness it is an evidence to prove that snacks don't undergo staling during storage.

Due to hygroscopic nature of dehydrated snacks which leads to absorption of water from atmosphere, moisture content also significantly increases with the time as 1.08^{a}± 0.00, 2.6^{b} ± 0.2, 2.88^{b} ± 0.01. Although here 300 guage HDPP bags were used for packaging, based on the above results recommendation is to have more detailed packing like vacuum packing to minimize the rise of moisture content.

P values for each and every sensory attribute are greater than 0.05 as shown in the below table 4, according to the Kruskal- Wallis non parametric test results. Therefore, there is no any significant change of attributes with the storage time which means that consumer acceptability won't change over time which ensures consumer demand which depends on sensory evaluation principles.

V. Conclusion

Banana snacks will help to provide a solution to the excessive banana production in Sri Lanka as well as in the same time, it adds value to banana which can be found throughout the year. There is no any significant change in the sensory attributes of snacks which maintains the consumer acceptability throughout the storage. Although there was no usage of artificial preservatives, the developed snacks can be stored without any quality deterioration until 2 months. Developed snack will be a best alternative for snacks or food products which are fried or preserved artificially due to its high composition of crude fiber and low free fat content (2.39 ± 0.005% crude fiber, 0.90 ± 0.01% free fat) based on the proximate analysis results.

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M.H.T.K. CHANDRASIRI. "Evaluation of nutritional, physicochemical and sensory properties of vacuum dehydrated seeni banana (Musa acuminata ABB) snacks." *IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 14(12), (2020): pp 31-36.