

Development and quality assessment of plantain flower [*Musa balbisiana* Colla] cookies: Beneficial for perimenopausal women

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SUMMARY

Background: *Musa balbisiana* Colla (Plantain flower) comprising of significant nutrients likely vitamins, minerals and phytochemical substituents such as flavonoids. The nutrients present in the plantain flower possess numerous therapeutic beneficiaries. The phytoestrogens commonly known as flavonoids act against the deficiency of estrogen and aid in achieving the quality health status of women. Although there are surplus quantity of plantain flowers in India, it is not used by several people in the nation. **Aim:** The present research aims to develop and evaluate the nutritional composition and shelf life of Plantain Flower (*Musa balbisiana* Colla) cookies. **Methods:** The plantain flower acquired from the farm has been processed as well as powdered. The cookies were prepared by utilizing plantain flower powder at the differential concentrations of 10%, 20%, and 30%. It is standardized by mixing with powdered sugar, jaggery, and butter. The sensory analysis of Plantain flower cookies was performed by 25 semi-trained panel members using a 9-point hedonic scale and the best-accepted product was nutritionally evaluated. **Results:** The study found that plantain flower cookies with 20% variation showed excellent overall acceptability compared to cookies with 10% and 30% variations. The cookies also had high nutritional content, with energy, carbohydrates, fat, protein, dietary fiber, sodium, potassium, calcium, magnesium, iron, and flavonoids. **Conclusion:** The nutritionally enriched plantain flower possessing surplus health beneficiaries will be utilized by incorporating them in the diverse nutritional food preparations for perimenopausal women.

Keywords: Plantain flower; cookies; therapeutic; shelf life; nutritional composition.

RESUMEN

Desarrollo y evaluación de la calidad de las galletas de flor de plátano [*Musa balbisiana* Colla]: beneficiosas para las mujeres perimenopáusicas

Antecedentes: *Musa balbisiana* Colla (flor de plátano) contiene nutrientes importantes, como vitaminas, minerales y sustituyentes fitoquímicos como los flavonoides. Los nutrientes presentes en la flor de plátano poseen numerosos beneficios terapéuticos. Los fitoestrógenos, comúnmente conocidos como flavonoides, actúan contra la deficiencia de estrógeno y ayudan a lograr un estado de salud de calidad en las mujeres. Aunque hay una cantidad excedente de flores de plátano en la India, varias personas en el país

no las utilizan. **Objetivo:** La presente investigación tiene como objetivo desarrollar y evaluar la composición nutricional y la vida útil de las galletas de flor de plátano (*Musa balbisiana* Colla). **Métodos:** La flor de plátano adquirida en la granja ha sido procesada y pulverizada. Las galletas se prepararon utilizando polvo de flor de plátano en concentraciones diferenciales de 10%, 20% y 30%. Se estandariza mezclándola con azúcar en polvo, jaggery y mantequilla. El análisis sensorial de las galletas de flor de plátano fue realizado por 25 miembros del panel semi-entrenados utilizando una escala hedónica de 9 puntos y el producto mejor aceptado fue evaluado nutricionalmente. **Resultados:** El estudio encontró que las galletas de flor de plátano con 20% de variación mostraron una excelente aceptabilidad general en comparación con las galletas con variaciones de 10% y 30%. Las galletas también tenían un alto contenido nutricional, con energía, carbohidratos, grasas, proteínas, fibra dietética, sodio, potasio, calcio, magnesio, hierro y flavonoides. **Conclusión:** La flor de plátano enriquecida nutricionalmente que posee beneficios excedentes para la salud se utilizará incorporándola en las diversas preparaciones alimenticias nutricionales para mujeres perimenopáusicas.

Palabras clave: Flor de plátano; galletas; terapéutico; vida útil; composición nutricional.

RESUMO

Desenvolvimento e avaliação da qualidade de biscoitos de flor de bananeira [*Musa balbisiana* Colla]: benéficos para mulheres na perimenopausa

Contexto: *Musa balbisiana* Colla (flor de bananeira) composta de nutrientes significativos, como vitaminas, minerais e substituintes fitoquímicos, como flavonoides. Os nutrientes presentes na flor de bananeira possuem inúmeros beneficiários terapêuticos. Os fitoestrogênios comumente conhecidos como flavonoides atuam contra a deficiência de estrogênio e auxiliam na obtenção do estado de saúde de qualidade das mulheres. Embora haja uma quantidade excedente de flores de bananeira na Índia, elas não são usadas por várias pessoas no país. **Objetivo:** A presente pesquisa visa desenvolver e avaliar a composição nutricional e o prazo de validade dos biscoitos de flor de bananeira (*Musa balbisiana* Colla). **Métodos:** A flor de bananeira adquirida na fazenda foi processada e também pulverizada. Os biscoitos foram preparados utilizando pó de flor de bananeira nas concentrações diferenciais de 10%, 20% e 30%. É padronizado pela mistura com açúcar de confeitiro, açúcar mascavo e manteiga. A análise sensorial dos biscoitos de flor de bananeira foi realizada por 25 membros do painel semi-treinados usando uma escala hedônica de 9 pontos e o produto mais bem aceito foi avaliado nutricionalmente. **Resultados:** O estudo descobriu que os biscoitos de flor de bananeira com 20% de variação apresentaram excelente aceitabilidade geral em comparação aos biscoitos com variações de 10% e 30%. Os biscoitos também tinham alto conteúdo nutricional, com energia, carboidratos, gordura, proteína, fibra alimentar, sódio, potássio, cálcio, magnésio, ferro e flavonoides. **Conclusão:** A flor de bananeira nutricionalmente enriquecida que possui benefícios excedentes à saúde será utilizada incorporando-os nas diversas preparações alimentares nutricionais para mulheres na perimenopausa.

Palavras-chave: Flor de bananeira; biscoitos; terapêutico; prazo de validade; composição nutricional.

1. INTRODUCTION

In the current world, the demand for nutritionally superior food has been increasing [1]. Also, the current trend emphasizes on the intake of nutritionally rich food products which are deduced from both leafy and non-leafy vegetables [2, 3]. The plantain flower (*Musa balbisiana* Colla Blossom) is the by-product of banana cultivation [4, 5]. The largest producer of bananas is India which produces around 13.90 million tons [6]. In India, the cultivation of bananas is

predicted to attain 35.5 million tons in 2029 and the cultivation in Asia is forecasted to reach 51.8% [7, 8].

Tamil Nadu ranks first in the production of banana cultivation in India and produced 118.04 hectares of crops in 2014 [9]. Moreover, Tamil Nadu alone produced 220 tons of banana blossoms in India [10]. The Banana blossom also known as the “banana flower” or “banana heart” can be eaten in raw or cooked form [11, 12]. Besides, the plantain flower is highly consumed in other Asian countries like Sri Lanka, Malaysia, Philippines, and Indonesia [13]. Compared to other countries, the cultivation and consumption of plantain flowers in Asian countries are higher due to their rich nutrients and anti-oxidants [14, 15].

The highest consumption of plantain flowers is due to their high protein, vitamin C, phytochemicals, mineral, and polyphenol content. Moreover, it is considered to have bioactive compounds such as flavonoids, saponins, polyphenols, phenols, triterpenes, tannins and diterpenes. The phytochemicals in the plantain flower act as antioxidants [16]. The anti-oxidant properties in *Musa balbisiana* Colla aid in preventing oxidative stress [17]. Plantain flower’s inflorescence contains cytotoxic characteristics and anti-oxidant activity [18]. The below Table-1 illustrates the Nutritional facts of Plantain Flowers per 100 g.

Table 1. Nutritional Analysis

Nutrients	Quantity (per 100 g)
Energy	51 kcal
Carbohydrate	8.79 g
Protein	1.63 g
Fat	0.50 g
Fiber	5.7 g
Beta-carotene	0.19 mg
Calcium	105 mg
Phosphorous	76 mg
Iron	3.5 mg
Copper	13 mg
Potassium	176 mg
Magnesium	56 mg
Flavonoids	137 mg

Banana blossoms are also high in phytochemical constituents, antioxidant properties, and medicinal benefits, making them a potential functional food with a huge amount of nutraceutical values that are essential for maintaining good health [19]. Some of the researchers have identified various phenolic acids in plantain blossom such as protocatechuic acid, p-hydroxybenzoic, gallic acid, vanillic acid, caffeic acid, catechol, gentistic acid, vanillin acid, and chlorogenic acid. Especially, some of the flavonoids such as epicatechin, rutin, catechin and quercetin have also been identified in the prevailing studies [20]. Plantain flower powder has enhanced the white blood cells as well as neutrophils that don’t affect the blood biochemistry as well as the enzyme-related liver function. Also, immune-related genes such as IL-10, HSP70, and TNF- α have been identified. The *Musa balbisiana* Colla powder with increased anti-oxidant enzyme activities has a significant effect on the liver tissue [21].

As per the nutritional composition of plantain flower, it has a significant source of protein, micronutrients and carbohydrates. This is utilized in the treatment of breast cancer, diabetics, the menstrual cycle, infection treatment, healing wounds, inflammatory bowel disease, and

inhibits AGE formation. Also, the consumption of plantain flowers on daily basis increases the hemoglobin level due to the presence of high fiber and iron. It aids in the production of red blood cells which reduces menstrual bleeding. Moreover, it regulates progesterone hormone and mitigates muscle cramps (Kavya M H et al., 2023) *Musa balbisiana* Colla has a great amount of phytochemicals for the food additive application, pharmacological and nutraceuticals [22]. This helps in reducing the post-prandial hyperglycemia which is considered as anti-diabetic agent [23]. It has rich fiber content which mitigates blood cholesterol and cardiovascular disease. Moreover, it has been utilized for treating constipation, bronchitis and ulcer [24]. It aids in increasing the red blood cells and promoting tissue repair [3].

Omar *et al.* [25] have established the nutritional value of the plantain flower powder. The research determined the radical scavenging activity of the plantain flower extract. As per the analysis, 500 mcg/mL of plantain flower extract has 56.66% antioxidant activity in the third trial. Thus, the researcher has highlighted the usage of plantain flowers as an anti-oxidant [25]. Sitthiya *et al.* [26] have identified the existence of tyrosine and tryptophan amino acid and also various peptides [26]. Moreover, Lau *et al.* [20] have highlighted that *Musa balbisiana* Colla has a significant amount of unsaturated fatty acids like linoleic, α -linolenic and oleic acids which mitigate the peril of cardiovascular disease [20]. Begum and Deka [16] have highlighted the concentration of plantain flower- 61.13-66.22 g/100 g (Total Dietary Fiber), 53.9-61.86 g/100 g (Insoluble Dietary Fiber) and 4.36-7.23 g/100 g (Soluble Dietary Fiber) [16].

In bakery products, cookies are one of the varieties which comprise various ingredients with sufficient fiber, vitamin C and protein [27]. Since cookies have a good shelf-life compared to other bakery products, various other research has developed cookies with black cumin seed, flax seed and sesame seed and evaluated their nutritional benefits [28]. Since baked food products are regarded as one of the significant foods in dietary plans, various nutritional ingredients have been incorporated to create the cookies [29]. Various studies have developed nutritional cookies using various nutritional food products [30, 31]. The cookies have been developed with ingredient which has the highest source of anti-oxidants, physicochemical properties, bio-active compounds, phenolic compounds and dietary fiber content in the food products [32, 33].

Bansal *et al.* [34] developed nutrient-dense cookies which has been enriched with micro-nutrients [34]. The researcher developed four types of cookies which consist of the control group, type1, type2 and type3. Control group does not have carrot and sesame powder whereas type1, type2 and type3 has 20%, 30% and 40% of carrot powder accordingly and 20% of sesame. The developed cookies have certain nutritional parameters such as protein, crude fat, fiber, and ash. Also, it has calcium, zinc and iron [35]. Hence, it depicted that cookies with carrot powder and sesame could be used to restrain malnutrition. Soares *et al.* [36] have developed cookies using wheat flour through cocoa bean shells which have higher bio-active compounds. The researcher identified phenolic compounds as well as total flavanol content in the developed cookies. The cocoa bean shell cookies have 1.68-2.37 mg gallic acid of phenolic compound and 0.10-0.19 mg epicatechin of total flavanol content [36].

Nonetheless, the prevailing studies failed to develop nutritional cookies that increase red blood cells and regulate menstrual bleeding, especially for perimenopausal women [37, 38]. The plantain flower powder with high amounts of protein, fiber, iron, calcium, magnesium and phytochemical compounds such as flavonoids and total phenol content could be used to develop cookies with a shelf life beneficial for perimenopausal women. Hence, the current study aims to develop and analyze the quality of cookies developed with plantain flowers (*Musa balbisiana* Colla).

2. MATERIALS AND METHODS

2.1. Processing of plantain flower powder

Evenly sliced plantain flower was immersed in the rice-rinsed water for about thirty minutes to mitigate the enzymatic browning reaction. Later, it has been sun-dried for about 4 to 6 hours and pulverized into fine powder.

2.2. Formulation of product

Plantain flower cookies were developed in the food science laboratory in the SRM Medical College Hospital and Research Centre's Clinical Nutrition Department in Kattankulathur. The cookies have been developed into three different combinations of plantain flower powder. The three variations of cookies were prepared by incorporating plantain flower powder in 10%, 20%, 30% and the Control group. The composition of different variations of plantain flower cookies is depicted in Table 2.

Table 2. Composition of variations of plantain flower cookies (100 g)

Ingredients	Variation -1	Variation- 2	Variation- 3	Variation-4 (Control Group)
Wheat flour	40 g	30 g	20 g	55 g
Plantain flower powder	10 g	20 g	30 g	-
Cocoa powder	-	-	-	5 g
Skimmed milk powder	10 g.	10 g	10 g	10 g
Jaggery	10 g	10 g	10 g	10 g
Powdered sugar	10 g	10 g	10 g	10 g
Butter	10 g	10 g	10 g	10 g
Vanilla essence	1 tsp.	1 tsp.	1 tsp.	1 tsp.
Baking powder	1 tsp.	1 tsp.	1 tsp.	1 tsp.
Salt	A pinch	A pinch	A pinch	A pinch
Choco chips	5 g	5 g	5 g	-
Dry raisins	5 g	5 g	5 g	-

2.3. Procedure for preparation of plantain flower cookies

The calculated amount of plantain flower powder, wheat flour, and skimmed milk powder was mixed in the large bowl and then 1 tsp of baking powder and vanilla essence were added respectively. Later, a pinch of salt is added and the ingredients are mixed well. The powdered sugar, jaggery, and butter were blended using the minimum amount of water in a mixer jar. The batter was added to the flour mixture and kneaded into a dough using a little water. Later, the calculated raisins were mixed with dough. The dough was made into small balls of 17 g. each. Using a cookie cutter, the small balls were given a round shape and later choco chips were added to the top of the cookies. Finally, the cookies were baked in the microwave oven at 180 °C for about 15 minutes (Figure 1(A-F)). A similar method was followed for making standard chocolate cookies except for plantain flower powder, choco chips, and raisins.

2.4. Sensory evaluation

The sensory evaluation was performed by 25 semi-trained panel members using a 9-point hedonic scale. All five parameters such as appearance, aroma, taste, texture, and sweetness were

evaluated on the hedonic rating scale of 1 to 9. It ranges from dislike very much to like very much. By using the formula, the product acceptability index (PAI %) was assessed [39].

$$\text{PAI \%} = \frac{\text{Average grade obtained for a product}}{\text{Maximum grade given to a product}} \times 100$$

2.5. Nutrient analysis of the best-accepted product

To assess the nutrient content of the best-accepted product the fat, protein, sodium, dietary fiber, iron and potassium, AOAC 20th edition (2016) was utilized. Using IS 5949:1990, the minerals like magnesium and calcium were evaluated. Furthermore, IS 12711:1989 method was employed to assess the moisture content. Through the GCMS method, flavonoids and total phenol content were assessed. The energy and carbohydrates were assessed through FAO and CTL/SOP/FOOD/262-2014 methods respectively.

2.6. Shelf-Life of the best-accepted product

The shelf life study of the plantain flower cookies was evaluated under varied conditions such as packing in aluminum foil ventilated bags as well as without ventilation and stored for two months. The cookies were stored under the ambient of 30±2°C and refrigerated (5°C). The plantain flower cookies were prepared and tested on the 0th, 10th, 20th, 30th, 40th, 50th, and 60th day for microbiological quality and the standard chocolate cookies (control group) were also analyzed on the 0th, 10th, 20th, 30th, 40th, 50th, 60th day for microbiological quality.

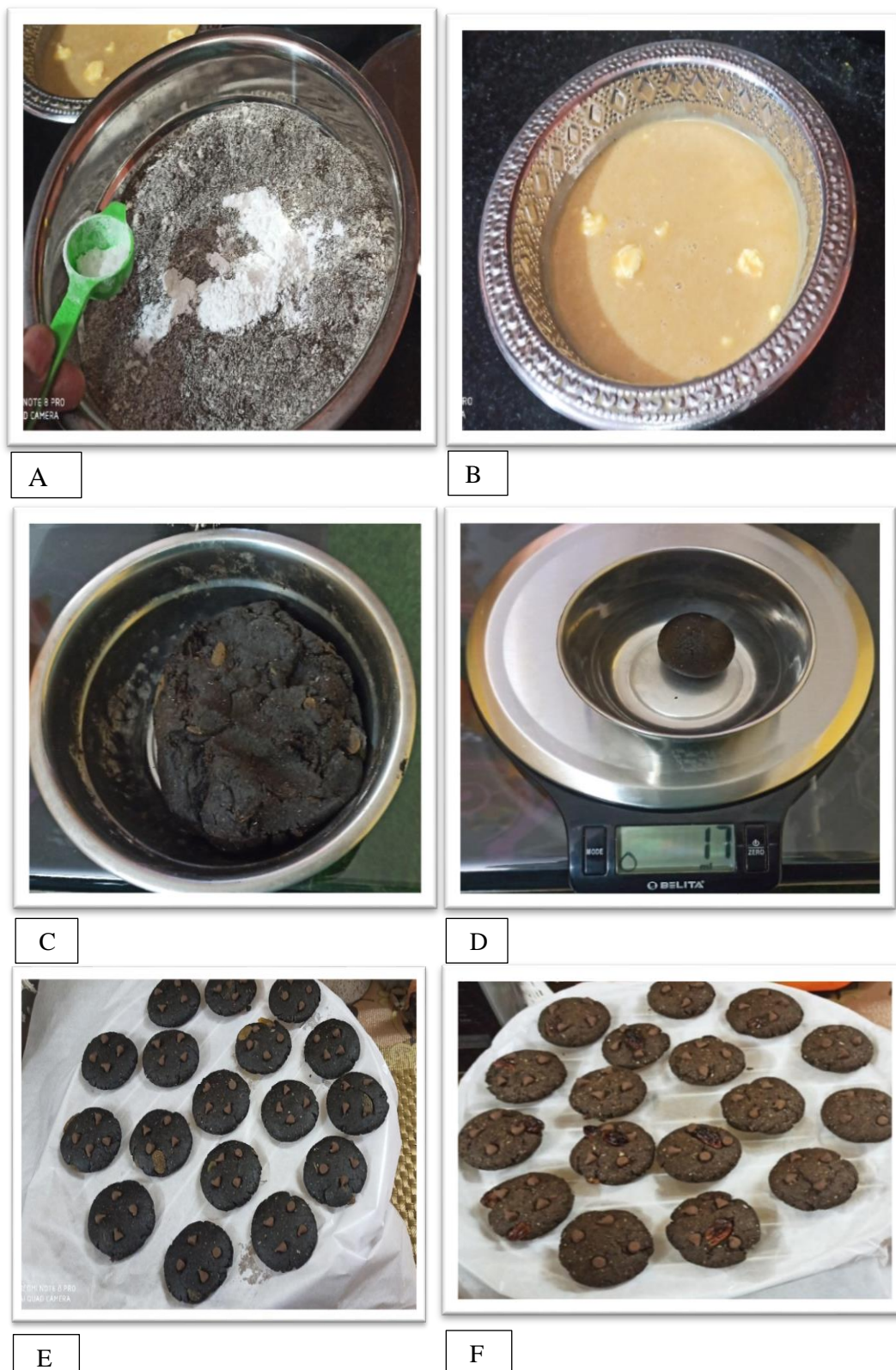


Figure 1. Preparation of Plantain flower cookies: (A) Mixture of wheat flour, plantain flower powder, milk powder with vanilla essence and baking powder, (B) jaggery, sugar and butter blended with little water, (C) batter and flour mixture kneaded to dough, (D) dough transferred to 17 g balls, (E) cookies topped with choco chips, (F) After baking.

3. RESULTS

3.1. Sensory Evaluation

The analysis of sensory parameters has been performed by the 25 semi-trained panel members to demonstrate the possible acceptability of novel products for achieving health benefits for women. Table 3 reveals the sensory evaluation of plantain flower cookie variants.

Table 3. Sensory evaluation of the *Musa balbisiana* Colla (plantain flower) Cookie Variants

Sensory parameters	Variants			p value
	V1 Mean±SD	V2 Mean±SD	V3 Mean±SD	
Appearance	2.32±1.75 ^a	8.80±0.41 ^c	4.08±2.02 ^b	0.000
Aroma	2.64±1.78 ^a	7.72±0.74 ^b	3.24±1.83 ^a	0.000
Taste	3.20±2.22 ^a	8.00±1.26 ^b	3.92±1.47 ^a	0.000
Sweetness	2.76±1.89 ^a	7.44±1.36 ^b	3.52±1.47 ^a	0.000
Texture	2.52±1.58 ^a	7.60±0.76 ^c	3.64±2.14 ^b	0.000
Overall Acceptability	6.24±0.78 ^b	8.24±0.66 ^c	2.52±0.87 ^a	0.000

Values are expressed as mean and standard deviation (n=25). Statistically significant at $p < 0.05$, where ^{a<b<c} indicates a significant difference in the parameters among the variants of *Musa balbisiana* Colla (plantain flower) cookies.

Table 3 illustrates the sensory parameters of the variants V1, V2 and V3. Meanwhile, V1 encompasses 10 g of plantain flower powder, V2 and V3 have 20 g and 30 g respectively. The appearance, aroma, taste, sweetness, texture are analyzed to detect the overall acceptability of the products. The appearance was found to be better in V2 cookies (8.80±0.41) compared to V1 (2.32±1.75) and V3 (4.08±2.02). Secondly, the aroma of the cookies was high in V2 variant (7.72±0.74) compared to V1 (2.64±1.78) and V3 (3.24±1.83). There is a rich taste in V2 (8.00±1.26) whereas V1 (3.20±2.22) and V3 (3.92±1.47) have a moderate taste (Figure 2). The sweetness is higher in V2 (7.44±1.36). Finally, the texture of the cookies has been analyzed and found to be 7.60±0.76. The overall acceptability among the three variants concluded by the panel member is V2 (8.24±0.66). Hence, V2 variant which encompasses 20 gm of plantain flower powder is the best variant compared to the other variants. The sensory parameters are higher in V2 cookies and it is considered to be an excellent cookie variant among others. Moreover, the significant value is less than 0.05 proving the noteworthy difference in parameters among the variants of plantain flower cookies.

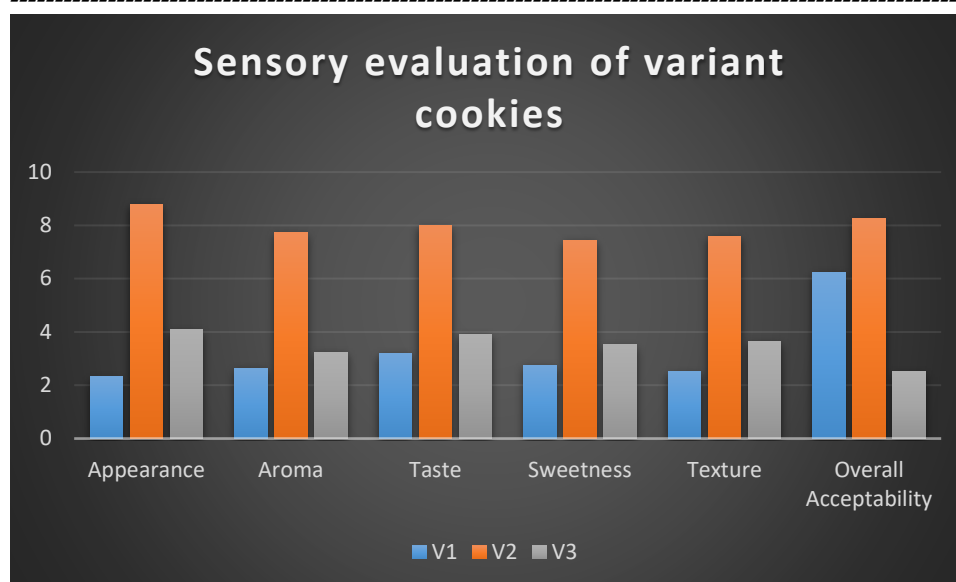


Figure 2. Sensory evaluation of the *Musa balbisiana* Colla (plantain flower) cookie variants

Table 4 illustrates the sensory evaluation of the organoleptically superior variant of plantain flower and control cookies. The sensory parameters of appearance, aroma, taste, sweetness, and texture are evaluated. The appearance of the V2 variant (8.80 ± 0.41) is comparatively higher than that of the control cookie (Figure 3). Moreover, V2 has an excellent aroma (7.72 ± 0.74), rich taste (8.00 ± 1.26), high sweetness (7.44 ± 1.36) and reliable texture (7.60 ± 0.76). Therefore, the overall acceptability is analyzed and calculated to be 8.24 ± 0.66 . A p-value less than 0.05 proves the significant differences between the plantain flower and control cookies.

Table 4. Comparison of sensory evaluation of organoleptically superior variant of *Musa balbisiana* Colla (Plantain Flower) cookies and control cookies

Sensory parameters	Sample	Mean \pm SD	t value	p value
Appearance	Control	4.28 \pm 1.86	11.867	0.000
	V2	8.80 \pm 0.41		
Aroma	Control	2.84 \pm 1.55	14.247	0.000
	V2	7.72 \pm 0.74		
Taste	Control	3.92 \pm 1.42	10.787	0.000
	V2	8.00 \pm 1.26		
Sweetness	Control	3.16 \pm 1.11	12.227	0.000
	V2	7.44 \pm 1.36		
Texture	Control	4.20 \pm 2.59	6.278	0.000
	V2	7.60 \pm 0.76		
Overall acceptability	Control	4.84 \pm 1.31	11.558	0.000
	V2	8.24 \pm 0.66		

Values are expressed as mean and standard deviation (n=25). Statistically significant at $p < 0.05$

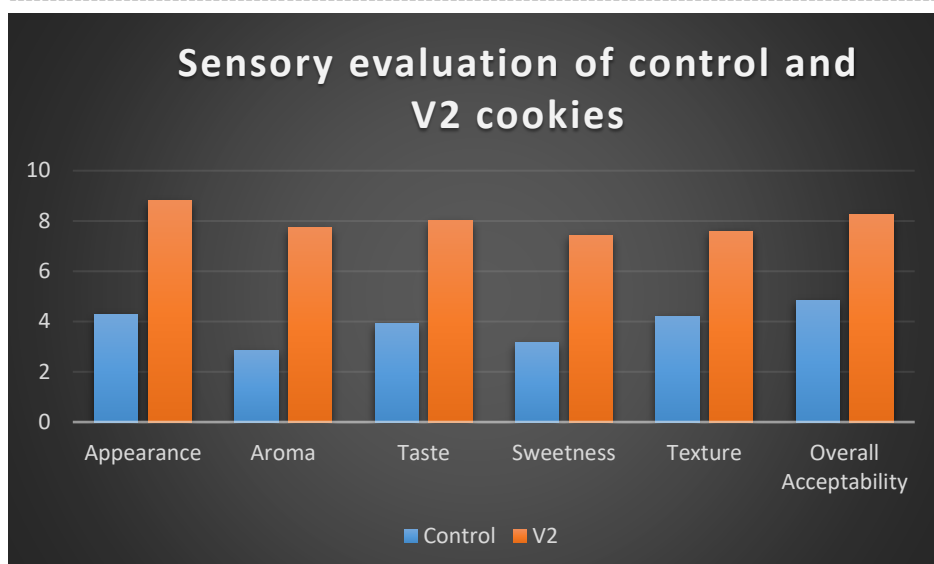


Figure 3. Sensory evaluation of V2 and control cookies

3.2. Nutritional analysis

The nutritional composition of plantain flower V2 cookies is 373.99 ± 9.90 kcal of energy, $66.53 \pm 2.25/100$ g of carbohydrate, $7.95 \pm 0.23/100$ g of total fat, 9.07 ± 0.23 g/100 g of protein, $9.69 \pm 1.27/100$ g of dietary fiber (Table 5). Moreover, plantain flowers V2 cookies have high amounts of micronutrients such as sodium (239.00 ± 34.83 mg/100 g) potassium (365.00 ± 22.11 mg/100 g), calcium (139.00 ± 32.45 mg/100 g), magnesium (131.33 ± 4.16 mg/100 g), and iron (4.80 ± 0.29 mg/100 g). The content of flavonoids (46.33 ± 11.06 mg/100 g) and phenol content (93.83 ± 8.75 mg/100 g).

Table 5. Nutrient composition of *Musa balbisiana* Colla (plantain flower) cookies- V2

Nutrients	Mean \pm SD
Energy (kcal/100 g)	373.99 \pm 9.90
Carbohydrates (g/100 g)	66.53 \pm 2.25
Total fat g/100g	7.95 \pm 0.23
Protein (g/100 g)	9.07 \pm 0.23
Dietary fiber g/100 g	9.69 \pm 1.27
Sodium (mg/100 g)	239.00 \pm 34.83
Potassium (mg/100 g)	365.00 \pm 22.11
Calcium (mg/100 g)	139.00 \pm 32.45
Magnesium (mg/100 g)	131.33 \pm 4.16
Iron (mg/100 g)	4.80 \pm 0.29
Moisture (g/100 g)	15.37 \pm 1.43
Flavonoids (mg/100 g)	46.33 \pm 11.06
Total phenol content (mg/100 g)	93.83 \pm 8.75

The nutritional composition of control cookies is 387.41 ± 7.54 kcal of energy, $67.7 \pm 2.17/100$ g of carbohydrate, $8.93 \pm 0.13/100$ g of total fat, 8.89 ± 0.38 g/100 g of protein, $8.00 \pm 0.02/100$ g of dietary

fiber (Table 6). Moreover, control cookies have high amounts of micronutrients such as sodium (338.00 ± 2.00 mg/100 g) potassium (305.00 ± 6.25 mg/100 g), calcium (118.00 ± 12.17 mg/100 g), magnesium (123.33 ± 19.14 mg/100 g), and iron (3.81 ± 0.37 mg/100 g). The content of flavonoids (27.80 ± 0.56 mg/100 g) and phenol content (70.00 ± 2.00 mg/100 g).

Table 6. Nutrient composition of standard chocolate cookies

Nutrients	Mean \pm SD
Energy (kcal/100 g)	387.41 \pm 7.54
Carbohydrates (g/100 g)	67.7 \pm 2.17
Total fat (g/100 g)	8.93 \pm 0.13
Protein (g/100 g)	8.89 \pm 0.38
Dietary fiber (g/100 g)	8.00 \pm 0.02
Sodium (mg/100 g)	338.00 \pm 2.00
Potassium (mg/100 g)	305.00 \pm 6.25
Calcium (mg/100 g)	118.00 \pm 12.17
Magnesium (mg/100 g)	123.33 \pm 19.14
Iron (mg/100 g)	3.81 \pm 0.37
Moisture (g/100 g)	114.07 \pm 0.67
Flavonoids (mg/100 g)	27.80 \pm 0.56
Total phenol content (mg/100 g)	70.00 \pm 2.00

The comparative analysis of the plantain flower and standard chocolate cookies are demonstrated. The energy, carbohydrate and total fat content are found to be higher in the standard chocolate cookies (Table 7). Since the carbohydrate content is low, which elevates the oil absorption making the dough appropriate for making cookies. Alternatively, the plantain flower variant V2 cookies are rich in protein and dietary fiber content (Figure 4). The high level of fiber content present in the plantain flower V2 cookies will improvise the digestion. The iron content is rich in the variant V2 cookies and less moisture content which makes the plantain flower cookies more crispier. The phenol content is higher in plantain flower V2 cookies. Therefore, the consumption of plantain flower V2 cookies might improve the health status than the standard chocolate cookies prevailed in the market.

Table 7. Comparison of nutrient composition of *Musa balbisiana* Colla (plantain flower) cookies- V2 and standard chocolate cookies- Control

Nutrients	V2 Mean \pm SD	Control Mean \pm SD	t value	p value
Energy (kcal/100 g)	373.99 \pm 9.90	387.41 \pm 7.54	1.867	0.135
Carbohydrates (g/100 g)	66.53 \pm 2.25	67.7 \pm 2.17	0.739	0.501
Total fat (g/100 g)	7.95 \pm 0.23	8.93 \pm 0.13	6.417	0.003
Protein (g/100 g)	9.07 \pm 0.23	8.89 \pm 0.38	0.714	0.515
Dietary fiber (g/100 g)	9.69 \pm 1.27	8.00 \pm 0.02	2.304	0.083
Sodium (mg/100 g)	239.00 \pm 34.83	338.00 \pm 2.00	4.915	0.008
Potassium (mg/100 g)	365.00 \pm 22.11	305.00 \pm 6.25	4.523	0.011

Calcium (mg/100 g)	139.00±32.45	118.00±12.17	1.050	0.353
Magnesium (mg/100 g)	131.33±4.16	123.33±19.14	0.707	0.518
Iron (mg/100 g)	4.80±0.29	3.81±0.37	3.595	0.023
Moisture (g/100 g)	15.37±1.43	114.07±0.67	1.428	0.227
Flavonoids (mg/100 g)	46.33±11.06	27.80±0.56	2.899	0.044
Total phenol content (mg/100 g)	93.83±8.75	70.00±2.00	4.598	0.010

Values are expressed as mean and standard deviation (n=3). Statistically significant at $p < 0.05$.

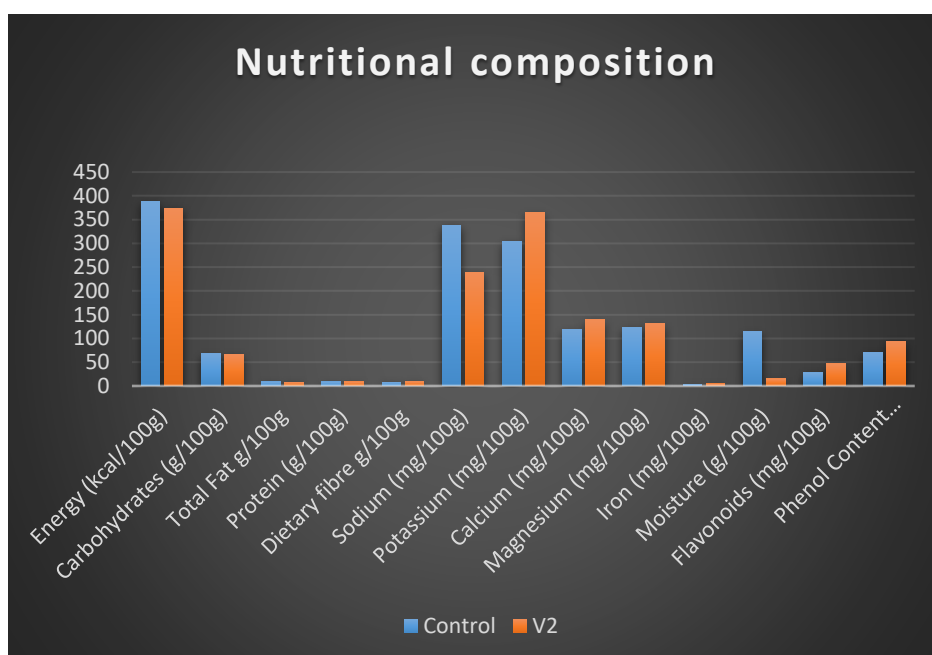


Figure 4. Nutrient composition of V2 and standard wheat cookies

3.3. Shelf life of the cookies

The shelf life of the plantain flower V2 cookies (experimental) and standard chocolate cookies (control) are analyzed. The significant “p” value and “t” value are estimated in order to assess the shelf life of the products for 10th, 20th, 30th, 40th, 50th and 60th days.

Table 8 illustrates the sensory parameters of the experimental and control cookies for the duration of 10, 20, 30, 40, 50 and 60th day. The color of the plantain flower cookies (9.00±0.00) are seems to be better than the standard wheat cookies (Figure 5). The color of the standard chocolate cookies gradually fades in the consecutive days of 20th to 60th. Comparatively, the experimental cookies are exhibiting attractive color rather than the standard chocolate cookies. The appeal of the plantain flower cookies are comparatively possessing higher scores than the standard wheat cookies (9.00±0.00). The taste and texture of the plantain flower cookies are also observed to be better than the standard wheat cookies (Figure 6). Finally, the overall acceptability of plantain flower cookies was observed to be most acceptable cookie. It also registers the significant value less than 0.05. In some of the parameters, the “t” value is not computed due to the similar standard deviation among two groups.

Table 8. Comparison of sensory qualities of the *Musa balbisiana* Colla (plantain flower) cookies- V2 and standard chocolate cookies- Control during the period of storage

Sensory parameter	Test day	Group	Mean±SD	t	P
Color	10th day	Experimental	9.00±0.00	4.58	0.00
		Control	8.30±0.48		
	20th day	Experimental	8.40±0.52	1.57	0.13
		Control	8.10±0.32		
	30th day	Experimental	8.20±0.42	4.44	0.00
		Control	7.30±0.48		
	40th day	Experimental	7.80±0.42	2.47	0.02
		Control	7.30±0.48		
	50th day	Experimental	7.80±0.42	3.13	0.01
		Control	7.10±0.57		
	60th day	Experimental	7.70±0.48	4.43	0.00
		Control	6.50±0.71		
Appearance	10th day	Experimental	9.00±0.00	3.00	0.01
		Control	8.50±0.53		
	20th day	Experimental	8.90±0.32	4.20	0.00
		Control	8.20±0.42		
	30th day	Experimental	8.30±0.48	1.96	0.07
		Control	8.00±0.00		
	40th day	Experimental	8.60±0.52	5.81	0.00
		Control	7.30±0.48		
	50th day	Experimental	8.10±0.32	5.40	0.00
		Control	7.20±0.42		
	60th day	Experimental	8.00±0.00	9.00	0.00
		Control	6.80±0.42		
Aroma	10th day	Experimental	9.00±0.00 ^a		
		Control	8.00±0.00 ^a		
	20th day	Experimental	8.80±0.42	6.00	0.00
		Control	8.00±0.00		
	30th day	Experimental	8.80±0.42	6.00	0.00
		Control	8.00±0.00		
	40th day	Experimental	8.70±0.48	5.81	0.00
		Control	7.40±0.52		
	50th day	Experimental	8.90±0.32	10.20	0.00
		Control	7.20±0.42		
	60th day	Experimental	7.80±0.63	3.76	0.00
		Control	6.70±0.67		
Taste	10th day	Experimental	9.00±0.00	3.67	0.00
		Control	8.40±0.52		
	20th day	Experimental	9.00±0.00 ^a		
		Control	8.00±0.00 ^a		
	30th day	Experimental	9.00±0.00 ^a		
		Control	8.00±0.00 ^a		
	40th day	Experimental	8.60±0.52	4.33	0.00
		Control	7.60±0.52		

	50th day	Experimental	8.30±0.48	4.02	0.00
		Control	7.40±0.52		
	60th day	Experimental	8.00±0.00	3.21	0.00
		Control	7.20±0.79		
Texture	10th day	Experimental	9.00±0.00 ^a		
		Control	9.00±0.00 ^a		
	20th day	Experimental	8.60±0.52	1.34	0.20
		Control	8.30±0.48		
	30th day	Experimental	8.40±0.52	2.45	0.02
		Control	8.00±0.00		
	40th day	Experimental	8.00±0.00	2.45	0.02
		Control	7.60±0.52		
	50th day	Experimental	7.70±0.48	1.85	0.08
		Control	7.30±0.48		
	60th day	Experimental	7.60±0.52	4.02	0.00
		Control	6.70±0.48		
Overall acceptability	10th day	Experimental	9.00±0.00	3.67	0.00
		Control	8.40±0.52		
	20th day	Experimental	8.80±0.42	2.47	0.02
		Control	8.30±0.48		
	30th day	Experimental	8.00±0.00 ^a		
		Control	8.00±0.00 ^a		
	40th day	Experimental	8.00±0.00	1.00	0.33
		Control	7.90±0.32		
	50th day	Experimental	7.90±0.32	2.06	0.05
		Control	7.50±0.53		
	60th day	Experimental	7.70±0.48	0.88	0.39
		Control	7.50±0.53		

Values are expressed as mean and standard deviation (n=10). Statistically significant at $p < 0.05$. ^a t cannot be computed because the standard deviations of both groups are 0.

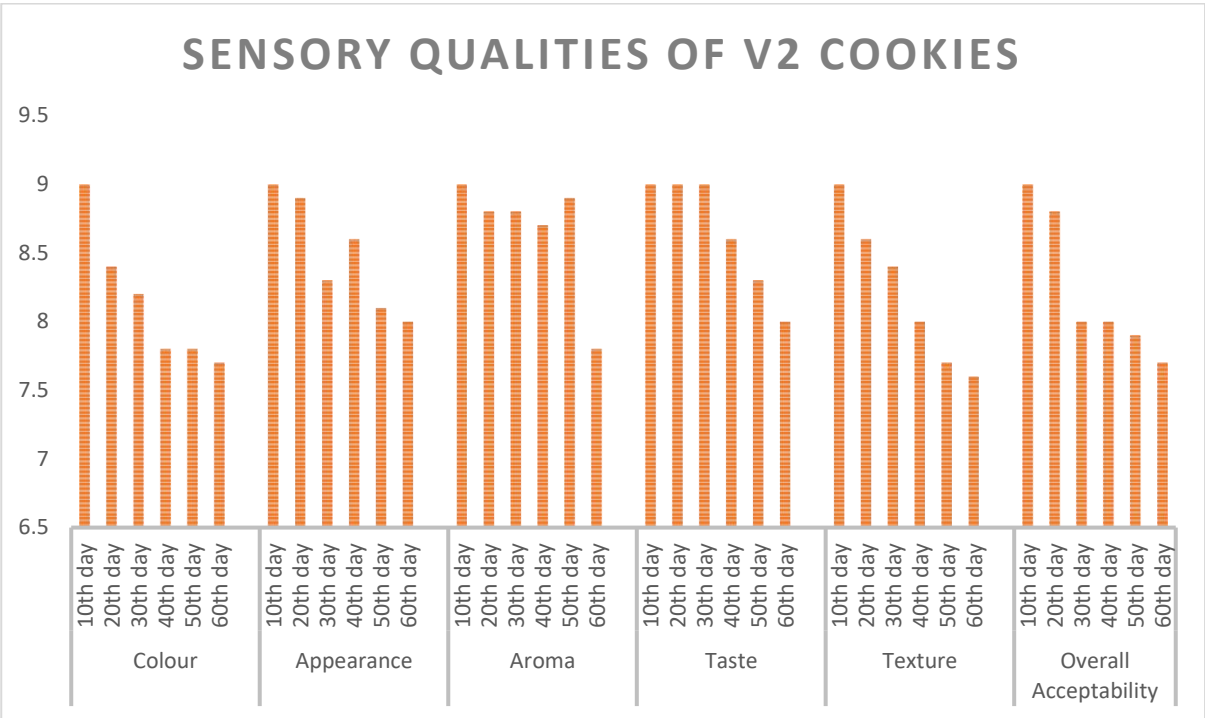


Figure 5. Sensory qualities of V2 cookies

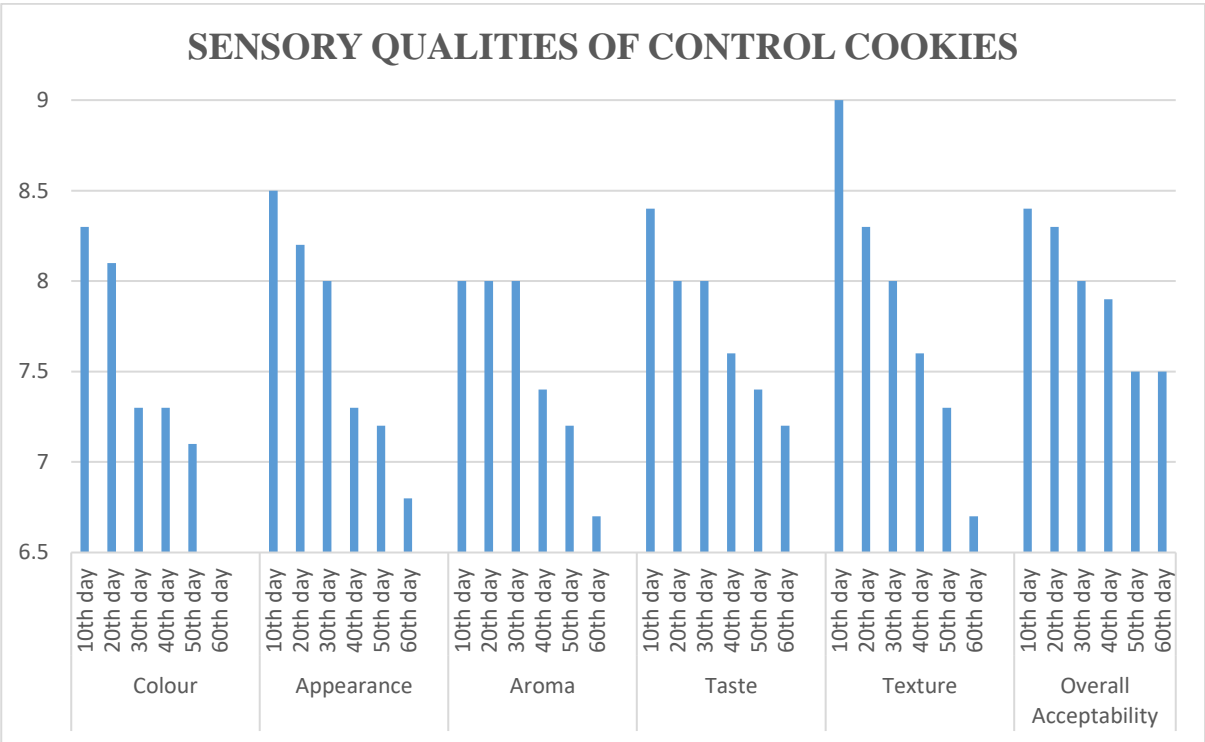


Figure 6. Sensory qualities of control cookies

Table 9 illustrates the chemical parameters of the experimental and control cookies for the duration of 10, 20, 30, 40, 50 and 60th day. The peroxide value of the plantain flower cookies (8.62±0.20 mcq/kg) seems to be better than the standard chocolate cookies. The value gradually elevates in the consecutive days of 20th to 60th. Comparatively, the experimental cookies exhibit higher peroxide value rather than the standard chocolate cookies. The moisture of the plantain

flower cookies possesses less value than the standard chocolate cookies (5.06 ± 0.02 g/m³). From the analysis, it has been proven that the moisture content of the standard chocolate cookies was higher and increased from 20th to 60th day of storage. The antioxidant capacity of the plantain flower cookies are also observed to be better than the standard chocolate cookies. Finally, the pH level of plantain flower cookies was observed to be greater than that of standard chocolate cookies. Both the cookies possess an acceptable value pH value of 5-6. Hence, from the above analysis the nutritional composition and shelf life of *Musa balbisiana* Colla has been evaluated and compared with the control group cookies.

Table 9. Comparison of chemical parameters of the *Musa balbisiana* Colla (plantain flower) cookies-V2 and standard chocolate cookies- Control during the period of storage

Sensory parameter	Test day	Group	Mean \pm SD	t	p
Peroxide value (mcq per kg of sample fat)	10th day	Experimental	8.62 \pm 0.20	6.26	0.00
		Control	7.62 \pm 0.20		
	20th day	Experimental	8.74 \pm 0.19	6.60	0.00
		Control	7.74 \pm 0.19		
	30th day	Experimental	8.90 \pm 0.21	6.24	0.00
		Control	7.89 \pm 0.19		
	40th day	Experimental	9.00 \pm 0.19	5.52	0.01
		Control	8.07 \pm 0.22		
	50th day	Experimental	9.12 \pm 0.12	3.98	0.02
		Control	8.38 \pm 0.30		
	60th day	Experimental	9.21 \pm 0.12	3.10	0.04
		Control	8.39 \pm 0.44		
Moisture Level (gm/m ³)	10th day	Experimental	5.06 \pm 0.02	1.14	0.32
		Control	5.13 \pm 0.12		
	20th day	Experimental	5.19 \pm 0.07	1.90	0.13
		Control	5.37 \pm 0.16		
	30th day	Experimental	5.29 \pm 0.05	4.88	0.01
		Control	5.60 \pm 0.10		
	40th day	Experimental	5.37 \pm 0.03	8.75	0.00
		Control	6.26 \pm 0.17		
	50th day	Experimental	5.44 \pm 0.03	8.78	0.00
		Control	6.39 \pm 0.19		
	60th day	Experimental	5.57 \pm 0.03	7.02	0.00
		Control	6.54 \pm 0.24		
Antioxidant Capacity	10th day	Experimental	17.81 \pm 0.52	1.41	0.23
		Control	17.13 \pm 0.64		
	20th day	Experimental	20.51 \pm 1.84	1.11	0.33
		Control	19.17 \pm 0.98		
	30th day	Experimental	23.30 \pm 2.52	0.89	0.42
		Control	21.63 \pm 2.05		
	40th day	Experimental	27.43 \pm 3.00	0.88	0.43
		Control	25.83 \pm 0.91		
	50th day	Experimental	31.07 \pm 3.23	0.67	0.54
		Control	29.70 \pm 1.47		
	60th day	Experimental	37.15 \pm 3.97	1.12	0.32
		Control	34.47 \pm 1.21		

pH Level	10th day	Experimental	5.74±0.02	2.03	0.11
		Control	5.37±0.32		
	20th day	Experimental	6.21±0.19	1.62	0.18
		Control	5.83±0.35		
	30th day	Experimental	6.38±0.14	- 0.07	0.95
		Control	6.39±0.10		
	40th day	Experimental	6.68±0.12	0.78	0.48
		Control	6.59±0.17		
	50th day	Experimental	6.80±0.02	0.69	0.53
		Control	6.77±0.06		
	60th day	Experimental	6.93±0.06	1.41	0.23
		Control	6.87±0.06		

Values are expressed as mean and standard deviation (n=3). Statistically significant at $p < 0.05$.

4. DISCUSSION

In the present research, the plantain flower cookies are found to be highly nutritious, since the plantain flower powder utilized in the cookies preparation are enriched with high nutrient content. Meanwhile, the cookies developed utilizing the plantain flower powder was found to be more nutritious compared to the standard wheat cookies [40]. Likewise, the cake prepared from the plantain flower subjected to rice rinsed water about thirty minutes seems to be highly nutritious compared to standard wheat cake [23]. The plantain flower cookies manufactured with the 20% variants found to be more acceptable compared to the 10 and 30% variants. Therefore, the product acceptability minimizes with the high level of incorporation of flour [41]. Likewise, the outcomes acquired by the researcher for the preparation of humus which incorporated the plantain flower powder in differential concentrations of 18 g, 20 g and 25 g [42]. The humus manufactured with the 20 g plantain flower powder was observed to be highly acceptable. Also, the present research conveys that 20 g of plantain flower powder has been proved to be optimal compared to 10 and 30 g variants.

The prevailing research by Zehla [43] reveals that the sensory test scores for overall acceptability of plantain flower powder shows that 35% variants was effectual compared to 50% and 60% variation. Moreover, 65% of plantain flower powder has the least score of taste and overall acceptability. The present research had the highest score of taste as well as acceptability with 20% variants compared with 10% and 30% variants. On contrary, the existing research by Tasnim *et al.* [23] revealed that amongst the four variants of the wheat bread developed by addition of plantain flower powder in the differential variation of 25%, 20%, 15% and 10%, the 10% variation observed to be the optimal product. The product acceptability varies with the concentration of plantain flower powder.

The cookies produced from Moringa leaf and fermented sweet detar shows the overall acceptability of 8.13 [44]. The sensory score of aroma (7.60), appearance (8.26), taste (7.60) and texture (7.46). The present research conveys that the plantain flower cookies has the overall acceptability of 9.00. Ertaş *et al.* [28] reported that the utilization of raw and roasted hemp flour elevates the total phenol content, protein, ash and fat content. The hemp flour content minimizes the hardness and leads to formation of softer cookies. The nutritional value of the cookies are found to be higher in the addition of hemp seed to cookies. The plantain flower cookies are also found to exhibit high nutritional content. Pinto *et al.* [29] conveys that the utilization

of chest-nut shell in the cookies production possessed carbohydrates (53.92%), fat (32.62%) and fiber (5.15%). The anti-oxidant effects evident the bioactivity of the cookies. The sensory evaluation has excellent scores in all parameters greater than 6.25. Moreover, the phenolic acids and flavonoids are present in the cookies. The plantain flower cookies has better scores in sensory attributes compared to control cookies.

The dietary fiber, fats, carbohydrates, phenolic contents of concentrated fiber powder from chiku were observed to be greater compared to the wheat flour cookies. On contrary, the moisture content and total protein content were lower in chiku cookies. The cookies found to be superior fiber source, phenolic content and scavenging activity. The cookies containing 7% of chiku fiber possess highest sensory score [45]. The plantain flower cookies with 20 g has high value of sensory parameters compared to the 10 and 30 g of plantain flower powder. The increased proportion of oat flour and fenugreek in the cookies elevates the mineral content, fiber, protein, ash. Also, it proves that the sensory attributes reduced with the elevating proportion of oat and fenugreek [46]. The plantain flower powder of 30 g (V3) variant cookies has less value of sensory attributes.

5. CONCLUSION

Plantain flowers enriched with the nutrients are intensively utilized to formulate cookies that aids to overcome the perimenopausal symptoms. According to the evaluated scores and overall analysis, the present research concludes that plantain flower cookies exhibits an ample quantity of nutrients. Moreover, it is observed to be quality products with satisfied sensory acceptance. A notable variation in the nutrient composition of plantain flower cookies detected probable utilization of plantain flower as a healthy ingredient in the cookies preparation. The cookies prevailed in the market, the nutrients were comparatively lesser due to by-products processing prior to the product formulation. The sensory evaluation and nutritional analysis evident that the plantain flower cookies exhibits better composition of nutrients compared to the standard chocolate cookies. Additionally, the anti-oxidant of plantain flower cookies are seems to be better than the standard wheat cookies. The anti-oxidant properties aids in achieving the quality life of consumers. The formulated plantain flower cookies retain its sensory characteristics till 60th day. Therefore, the present research develops the nutritional enriched cookies with plantain flower which contributes to the incredible women community who suffers from perimenopausal symptoms and it generates nutritional awareness to the community.

CONFLICT OF INTEREST

All authors report that they do not have any conflicts of interest.

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