



Characterization of Proximate, Phytochemical and Antioxidant Analysis of Banana (*Musa sapientum*) Peels/Skins and Objective Evaluation of Ready to Eat /Cook Product made with Banana Peels

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Abstract

Banana (*Musa sapientum*) is usually consumed as a ripe fruit or cooked form. The peels/skins are considered as a waste product. It is important to determine any potential uses for these peels as they contribute to environmental problem due to its nitrogen and phosphorous content. The present study was aimed to evaluate and compare the nutritional compounds such as proximate principles, total phenols, flavonoids and tannin according to AOAC methods between the two varieties of banana peels from USA and India. The study also identified the anti-nutrients like saponin in the banana peel. It could also be used as a functional food. The proximate principles of USA variety peels estimated were 9.4% 6.7% and 11.5% for protein, fat and fiber. The India variety peel indicate the percentage of 11.7, 3.6 and 14.4 for protein, fat and fiber respectively. These peels also had a significant amount of total phenols, flavonoids and tannin. Therefore these peels could be incorporated into value-added foods and can serve as a functional food. Extruded product and pasta were formulated using the banana peel powder at 5 % level of incorporation. Colour and texture profile analysis of the developed extruded product and pasta was determined by selected objective method. The results from the present research showed that the banana peel powder showed an improved nutritional composition. The incorporation of 5% banana peel powder in the production of extruded product and pasta were not significantly affected the color and texture profile analysis.



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Introduction

Banana (*Musa sapientum*) is globally cultivated and usually consumes as a fruit or the raw form is used in cooking. Banana is a very popular fruit

because of its low price and presence of high nutrients. The peel or skin is usually considered as a waste product due to environmental pollution. Therefore it's highly recommended to determine

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the uses of these peels in food products as they are packed with antioxidants and polyphenols. The worldwide production of bananas is estimated to be 72.5 million metric tonnes, out of which India contributes 21.8 million metric tonnes. The other countries like Uganda, China and Philippines are the next largest producer in the world¹. Based on the literature, it was found that banana peel is rich in phytochemical compounds than the pulp. In addition, banana peel also has anti-fungal, antibiotic properties which can be used for health benefits on humans²⁻³. The literature survey discloses that information on GC-MS analysis of banana peel is limited.

Research trends focus on characterization and extraction of natural antioxidants and highlighting in disease prevention. As these compounds are present in many of the fruit peels, it would be worthwhile investigating the nature of these bio-active compounds that are present in banana peel. The present study was aimed to evaluate and compare the nutritional compounds such as proximate principles, total phenols, flavonoids and tannin according to AOAC⁴ methods between the two varieties of banana peels from USA and India. The study also identified the anti-nutrients like saponin in the banana peel. It could also be used as a functional food.

Methodology

Nutrient Analysis of Banana Peels/Skins

Organic Bananas (*Musa*) at the color index of 4 (greenish more yellow than green) according to the USDA banana ripening guide⁵ were purchased in one lot from COSTCO, Illinois, USA- 60305. In India, poovan banana were purchased in one lot from the local market at Thanjavur, Tamilnadu, India. Poovan is an important variety of banana which is especially grown for fruit purpose. Tamilnadu is the leading producer of poovan variety owing to its marginal soil and climatic condition. The fruit is slightly acidic, firm and has sweet aroma.

Preparation of Banana Peel Powder (US variety)

The US variety was dried in a Presto Dehydro electric food dehydrator. The peels/skins were removed from the flesh with the aid of stainless steel knife. The edges from the banana were cut and discarded.

The peels were sliced into 2 inches and these peels were laid on the dehydrator tray. There was enough space left on the tray to allow sufficient air flow for drying. Put the trays into the dehydrator and it operates at a pre set temperature of approximately 165° Fahrenheit. The general dehydrating information were followed and plug cord into 120 VAC electrical outlet and begin dehydrating for 4 hours. Then it was ground into powder with a mechanical blender. The powdered samples obtained were thereafter stored in clean airtight container at room temperature ($30 \pm 2^{\circ}\text{C}$) until needed for use.

Preparation of Banana Peel Powder (India Variety)

Radio frequency (RF) sterilizer is a promising technology for dehydration because of the faster, uniform heating and less drying time, larger penetration depth and energy efficiency. Radio frequency sterilizer has been applied successfully for drying of agricultural/food products, thawing of frozen foods, tempering, post-baking drying, pasteurization and roasting. During RF heating, direct heat is generated within the food product due to molecular friction. This friction results in oscillation of molecules and ions caused by the applied electric field. The speed of light waves is 3 lakhs Km/sec. This offers low and no fat, chemical free safe products, since it uses electromagnetic energy of longer wavelength than microwaves. It tends to drive the moisture from inside outward equalizing moisture throughout the product and avoids overheating and over dehydration of the food product⁶. The resistance to heat of various microorganisms like bacteria and pest types is the same under dielectric treatment as any other heating technique. For example molds and yeasts are killed more rapidly than bacteria. The banana peels were placed in the trays of the sterilizer and it were allowed to pass five times in the RF sterilizer.

Gas Chromatography Mass Spectrometry (GC-MS) analysis

Perkin Elmer GC Claurus 500 system with an Elite 5-MS fused silica capillary column composed of 5% Diphenyl and 95% Dimethyl poly siloxane and Turbo Mass Version 5.2.0 software was used. 70eV of the ionization energy was used. Helium gas was used as a carrier at a constant flow rate of 1 ml / minute. 2 µl of the sample were injected into the column. Initially the oven temperature was 110°C and later it was

increased to 200°C and finally with the increment of 280°C. It was estimated that total time for running was forty minutes.

MS Programme

The molecular weight and name of the compounds were identified using NIST Version 2.0 library database of National Institute Standard and Technology (NIST).

Analysis of Nutrient Parameters of Banana Peel Powder

The banana peel powder were analyzed for its proximate analysis such as moisture, protein, fat, fiber, carbohydrate, energy and ash content as per their respective methods described (AOAC)⁴ at Indian Institute of Food Processing Technology, Ministry of Food Processing Industries, Government of India, Thanjavur, India. All the analyses were performed in triplicates and the results were averaged.

Standardization of Extruded Product and Pasta

The standardization of extruded product and pasta were carried out at Indian Institute of Food Processing

Technology, Ministry of Food Processing Industries, Government of India, Thanjavur, Tamilnadu, India. Food extrusion is still an art though in recent years several researchers have aimed at understanding extrusion phenomenon in the light of the effect of extruder dimensions, the geometry of sewer and die, length to diameter ratio of extrudes and barrel grooves⁷.

The extruded product is very popular across various sections of the people, especially among the school going children and young people. It is a popular snack food or lunch box item. The various types of food products manufactured by extrusion typically have high starch content⁸. Therefore, the extruded product has to be made nutritionally better by enhancing the nutrients. Extruded product was prepared by replacing corn flour with the incorporation of banana peel powder at 5 per cent proportions. The ingredients used in preparation of extruded product are given in Table 1

Table 1: Ingredients Used In Extruded Product

Ingredients	Control extruded product	Replacing corn flour with 5% Banana peel powder
Corn flour (g)	1200	1140
Rice flour(g)	800	800
Banana peel powder	0	60
Salt(g)	50	50
Chilli powder(g)	50	50
Water(ml)	150	150

The above ingredients were separately weighed and mixed together in a blender for 30 minutes. The dry mixture was passed through a pre-conditioner. The cooking process was started by the injection of steam and the extrudate was then passed through an extruder. The final product usually puffs and changes in texture because of the force reduction and release of moisture and heat. The temperature for the extruder was adjusted to initial temperature of 52.3°C and final temperature of 110°C. The extrudate was then cut to the desired length by blades at the output of the extruder, which rotate around the die

openings at a specific speed. The product was then cooled and dried and finally packed in a zip lock bags.

Pasta Preparation

Soak rice flour, maize flour, wheat flour, banana peel powder, chilli powder and salt together with water and the dough formed was drawn between rolls of a pasta machine. It was then passed for steaming and then, fresh pasta was dried in a tray drier at 50°C for 4 hours. The dried pasta was finally packed in a zip lock bags for further analysis.

Table 2: Ingredients Used In Pasta

Ingredients	Control pasta	Replacing corn flour with 5% Banana peel powder
Maize flour (g)	1080	1020
Rice flour (g)	800	800
Wheat flour(g)	120	120
Banana peel powder(g)s	0	60
Salt(g)	50	50
Chilli powder(g)	50	50
Water(ml)	150	150

Colour and Texture Profile Analysis of Extruded Product and Pasta

The colour of the extruded product and pasta were determined by the color hunter colorimeter. The colour of the extruded product and pasta were evaluated by measuring the L (100 = white and 0 = black), a {red (+) and green (-)} and b {yellow (+) and blue (-)} value with a standard white tile⁹. The colour and texture profile analysis was replicated for three times. Texture analysis of banana peel incorporated extruded product and pasta were done by Texture Analyzer (Make Stable Micro System, U.K, Model TA -XT2). The colour and texture profile analyses were replicated for three times. Texture analysis of extruded product and pasta was done

by two methods such as Texture Analysis (TA) and Texture Profile Analysis (TPA) test. TA test was done for measuring cutting force of extruded product and TPA test for hardness, cohesiveness, gumminess, chewiness, resilience and springiness¹⁰.

Results and Discussion

The results obtained from the present study are discussed as follows:

Analysis of Proximate Principles of Banana Peel Powder from USA and India

The analysis of proximate principles of banana peel powder was triplicated and the results are depicted in the following Table-III

Table 3: Analysis of proximate principles, minerals and vitamin-C of banana peel powder per 100 grams

Proximate principles	USA/India Variety	Mean ± S.D	t- value	Significance
Moisture (%)	USA Variety	22.06± 0.01	1535.83	0.000
	India Variety	9.52 ± 0.01		p<0.001
Protein (g)	USA Variety	9.42±0.02	209.97	0.000
	India Variety	11.63±0.01		p<0.001
Fat (g)	USA Variety	6.65±0.01	368.64	0.000
	India Variety	3.64±0.01		p<0.001
Fiber (g)	USA Variety	11.51±0.01	355.17	0.000
	India Variety	14.41±0.01		p<0.001
Carbohydrate (g)	USA Variety	38.06±0.01	1199.02	0.000
	India Variety	47.85±0.01		p<0.001
Energy (Kcals)	USA Variety	249.65±0.01	2580.53	0.000
	India Variety	270.72±0.01		p<0.001
Ash (%)	USA Variety	12.35±0.01	73.48	0.000
	India Variety	12.95±0.01		p<0.001
Calcium (mg/Kg)	USA Variety	34.02±0.01	2933.96	0.000
	India Variety	64.96±0.02		p<0.001
Sodium(mg/Kg)	USA Variety	3.01±0.01	120.02	0.000
	India Variety	3.99±0.01		p<0.001
Vitamin C(mg/100 g)	USA Variety	60.70±0.01	374.77	0.000
	India Variety	91.30±0.01		p<0.001

NS-Not Significant, Mean ± SD of triplicates determination

Table: III summarizes the results of proximate principles, minerals and vitamin-C of two varieties of banana peel powder. The content of carbohydrate, protein and fiber seems to be higher for India variety peel. Fat content were higher in USA variety (6.65%). This value depicts that the peel could be a good source of carbohydrate and fiber. The result of moisture content was lower for India variety of 9.52%. This low value may be due to the time of harvest. The lower value, longer the shelf life for banana without mold growth. According to Mircini *et al.*,¹¹, 1997

these peels are good sources of minerals. These results indicate that peels have a concentration of 3 mg/Kg of sodium and higher amount of calcium were observed in India variety. The high calcium content also indicates that the peels could help treat Calcium- deficiency disorders and improve bone health. Vitamin-C content was high in India variety (91mg/100mg) when compared to USA variety (61 mg/100g). It was found by Kanazawa *et al.*,¹², 2002 that the ascorbic acid content of banana peel and pulp was constant at 10mg/100g.

Table 4: Total phenol, Flavonoids, Tannin and saponin content in banana peel powder per 100 g

Parameters	US/India Variety	Mean \pm S.D	t- value	Significance
Total phenol(mg/100g)	USA Variety	235 \pm 1.00	93.08	0.000 p<0.001
	India Variety	159 \pm 1.00		
Flavonoids (mg QE/ g)	USA Variety	1.23 \pm 0.15	4.42	0.011 p<0.001
	India Variety	1.70 \pm 0.01		
Tannin (mg/100 g)	USA Variety	152 \pm 1.00	30.61	0.000 p<0.001
	India Variety	127 \pm 1.00		
Saponin (mg/100 g)	USA Variety	7.75 \pm 0.01	232.70	0.000 p<0.001
	India Variety	9.65 \pm 0.01		

NS-Not Significant, Mean \pm SD of triplicates determination

The total phenol, flavonoids, tannin and saponin content of two banana peel extracts is shown in Table: IV. From the results, it is inferred that USA variety extract showed higher phenol and tannin content compared to India variety, which could be due to its antioxidant potential. Wide applications of phenols include as an antioxidant, anti-carcinogenic and also aids in decreasing the complications of cardiovascular diseases. In this study from the Table: IV values, India variety peel extract exhibited higher flavonoids content. The results of anti-nutritional factors indicate the saponin concentration to be 7.75mg for USA variety and 9.65 mg for India variety. The value obtained is slightly high when compared

to the study conducted by Kumar *et al.*,¹³, 1991. He found that 3% as the minimum safe value. Dietary saponin has a positive effect by decreasing the serum and tissue cholesterol levels in animals.

The identified compounds with their retention time, molecular weight and molecular formula and peak area percent are given in Table- V and VI respectively. Fourteen compounds were identified from USA variety banana peel extract and 11 compounds from India variety banana peel extract. The maximum peak was shown by Cyclolanostan-3- ol 38, acetate in USA and India variety peel extract.

Table 5: GC-MS analysis of bioactive components in USA variety banana peel powder

Sl. No	Retention time	Name of the compound	Molecular formula	Molecular Weight	Peak area Percent
1	4.51	4H-Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl	C ₆ H ₈ O ₄	144	0.54
2	5.82	5-Hydroxymethylfurfural	C ₆ H ₆ O ₃	126	1.31
3	8.38	Propanedioic acid, 3- thienyl	C ₇ H ₆ O ₄ S	186	1.10
4	9.65	Sucrose	C ₁₂ H ₂₂ O ₁₁	342	3.31
5	15.46	n-Hexadecanoic acid	C ₁₆ H ₃₂ O ₂	256	0.36
6	18.24	Octadecanoic acid	C ₁₈ H ₃₆ O ₂	284	0.46
7	20.09	Oleic acid	C ₁₈ H ₃₄ O ₂	282	0.19
8	26.23	Aromadendrene oxide-(2)	C ₁₅ H ₂₄ O	220	1.03
9	32.39	α- Tocopheryl acetate	C ₃₁ H ₅₂ O ₃	472	1.51
10	35.08	Stigmasterol	C ₂₉ H ₄₈ O	412	2.49
11	36.22	4,22- Stigmastdiene-3-one	C ₂₉ H ₄₆ O	410	5.51
12	36.59	9,19-Cyclolanost-23-ene-3,25-diol,(3β,23E)	C ₃₀ H ₅₀ O ₂	442	18.13
13	38.08	9,19-Cyclolanost-24-en-3- ol, acetate, (3β)	C ₃₂ H ₅₂ O ₂	468	31.45
14	38.47	9,19-Cyclolanostan-3- ol, acetate, (3β)	C ₃₂ H ₅₄ O ₂	470	32.61

Table 6: GC-MS analysis of bioactive components in India variety banana peel powder

Sl. No	Retention time	Name of the compound	Molecular formula	Molecular Weight	Peak area Percent
1	4.51	4H-Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl	C ₆ H ₈ O ₄	144	2.64
2	5.82	5-Hydroxymethylfurfural	C ₆ H ₆ O ₃	126	17.00
3	8.38	Propanedioic acid, 3- thienyl	C ₇ H ₆ O ₄ S	186	0.99
4	10.01	2,3-Anhydro-d-galactosan	C ₆ H ₈ O ₄	144	2.95
5	15.46	n-Hexadecanoic acid	C ₁₆ H ₃₂ O ₂	256	1.64
6	17.16	9,12-Octadecadienoic acid(Z,Z)	C ₁₈ H ₃₂ O ₂	280	0.86
7	32.38	Vitamin -E	C ₂₉ H ₅₀ O ₂	430	0.27
8	35.08	Stigmasterol	C ₂₉ H ₄₈ O	412	0.95
9	36.68	B- Sitosterol	C ₂₉ H ₅₀ O	414	2.65
10	38.08	9,19-Cyclolanost-24-en-3- ol, acetate, (3β)	C ₃₂ H ₅₂ O ₂	468	16.4
11	38.47	9,19-Cyclolanostan-3- ol, acetate, (3β)	C ₃₂ H ₅₄ O ₂	470	53.65

Standardization of Extruded Product and Pasta Colour Analysis of Extruded Product

The colour of the banana peel incorporated extruded product was determined by the color

hunter colorimeter and the results are shown in the following Tables.

Table 7: Colour Analysis Of Banana Peel Incorporated Extruded Product

Variables	Sample	Mean \pm S.D	t- value Control Vs5%	Significance Control Vs5%
L	Control	48.56 \pm 2.00	7.965	0.001p<0.001
	5%	39.36 \pm 0.02		
a	Control	7.33 \pm 0.36	20.50	0.000p<0.001
	5%	2.78 \pm 0.12		
b	Control	13.54 \pm 1.20	10.90	0.000p<0.001
	5%	7.03 \pm 0.35		

NS-Not Significant

Colour is one of the most important parameter in evaluating the developed extruded product and pasta. It not only reflects the suitable ingredients used for the preparation but also provides information about the formulation and quality of the product. Shahzag Hussain *et al.*,¹⁴, 2006 showed that increased level of addition of flax seed flour resulted in dark brown

colour of the cookies. It can be depicted from the above table that mean value for L was found to be 48.56 \pm 2.00 for control extruded product, 5 per cent of extruded product had 39.36 \pm 0.02. The value for "a" and "b" were found be significant among the control and 5% banana peel incorporated extruded product.

Table 8: Colour Analysis Of Banana Peel Incorporated Pasta

Variables	Sample	Mean \pm S.D	t- value Control Vs5%	Significance Control Vs5%
L	Control	34.97 \pm 0.02	20.96	0.001p<0.001
	5%	34.55 \pm 0.03		
a	Control	3.32 \pm 0.01	4.90	0.008p<0.001
	5%	3.28 \pm 0.01		
b	Control	5.53 \pm 0.01	4.90	0.000p<0.001
	5%	5.34 \pm 0.02		

NS-Not Significant

It can be depicted from the above table that mean value for L was found to be 34.97 \pm 0.02 for control product, 5 per cent of pasta had 34.55 \pm 0.03. The value for "a" and "b" were found be significant among the control and 5% banana peel incorporated pasta.

Texture Profile Analysis of Extruded Product and Pasta

The Table IX and show the texture profile analysis of extruded product and pasta.

Extrusion technology is the widely used technique for the development of snack foods. Texture plays a vital role, with crispiness being often a desirable parameter. Instrumental analysis has been a useful tool for food industry and manufacturers and it has been related to sensory evaluation. Extruded food products are generally composed of cereals, starches and proteins. These ingredients contribute structure, mouth feel and texture¹⁵. The physical properties of extruded rice flour and rice grain were determined using the Instron machine and the

Warner-Bratzler cutting device¹⁶. Liu *et al.*,¹⁷ (2000) conducted a TPA of extruded oat-corn puffs and established a high correlation with human sensory perception of specific textural attributes. It was found that there were no significant difference in the texture profile analysis between the control and 5 % incorporated extruded product

Banana contains a high proportion of indigestible compounds like resistant starch and non starch polysaccharides. The use of banana peel flour decreased the lightness. The texture analysis like hardness, fracturability, adhesiveness, springiness and chewiness were not affected by the incorporation of 5 % banana peel powder.

Table 9: Texture profile analysis of extruded product

Variables	Sample	Mean ± S.D	t- value	Significance
			Control Vs 5%	Control Vs 5%
Hardness	Control	1.481±0.001	-2.449	0.07
	5%	1.483±0.001		
Fracturability	Control	1.647±0.001	-1.835	0.14
	5%	1.652±0.004		
Adhesiveness	Control	1.814±0.001	-1.225	0.29
	5%	1.81500±0.001		
Springiness	Control	1.981±0.001	0.000	1.00
	5%	1.981±0.001		
Cohesiveness	Control	2.148±0.001	1.225	0.29
	5%	2.147±0.001		
Gumminess	Control	2.314±0.001	2.449	0.07
	5%	2.312±0.001		
Chewiness	Control	2.481±0.001	-0.562	0.6
	5%	2.483±0.006		
Resilience	Control	2.648±0.001	3.674	0.02
	5%	2.645±0.001		

Table 10: Texture profile analysis of extruded product

Variables	Sample	Mean ± S.D	t- value	Significance
			Control Vs 5%	Control Vs 5%
Hardness	Control	1.481±0.001	-74.000	0.000
	5%	1.530±0.000		
Fracturability	Control	1.647±0.001	-63.687	0.000
	5%	1.699±0.001		
Adhesiveness	Control	1.814±0.001	-63.687	0.29
	5%	1.866±0.001		
Springiness	Control	1.981±0.001	0.000	0.000
	5%	2.304±0.001		
Cohesiveness	Control	2.148±0.001	-66.136	0.000
	5%	2.202±0.001		

Gumminess	Control	2.314±0.001	-69.810	0.000
	5%	2.371±0.001		
Chewiness	Control	2.481±0.001	-0.355	0.740
	5%	2.496±0.075		
Resilience	Control	2.648±0.001	-71.035	0.000
	5%	2.706±0.001		

Conclusion

The results from the present research showed that the banana peel powder showed an improved nutritional composition. The proximate principles of USA variety peels estimated were 9.4% 6.7% and 11.5% for protein, fat and fiber. The India variety peel indicate the percentage of 11.7, 3.6 and 14.4 for protein, fat and fiber respectively. These peels also had a significant amount of total phenols, flavonoids and tannin. The incorporation of 5% banana peel powder in the production of extruded product and pasta were not significantly affected the color and texture profile analysis. Hence banana

peel can be exploited for their nutritional and bio-active components. Therefore these peels could be incorporated into value-added foods and their efficacy can be studied by human supplementation studies.

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