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Functional, Physicochemical and Anti-oxidant properties of Dehydrated Banana Blossom Powder and its Incorporation in Biscuits

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Abstract: Aim of this work is to develop good nutritional and high fibre biscuits by incorporation of banana blossom powder. An easily perishable banana blossoms were pretreated with citric acid solution (PCAS) and rice rinsed water (PRRW) to minimize enzymatic browning reaction and then dehydrated. The dehydrated banana blossoms were powdered and also determined its functional properties (swelling power and solubility, foaming capacity and stability, bulk density, least gelation concentration), physicochemical properties (pH, water and oil holding capacity and colour analysis) and antioxidant properties (radical scavenging assay and total phenol content). The nutritional values of fresh blossom, the dehydrated one and biscuits were analyzed according by the method of Association of Official Analytical Chemists (AOAC). Results suggested that the blossom PRRW could be a better source for the dietary supplement than the other.
Keywords: Banana blossom, pretreatment, functional properties, physicochemical properties, antioxidant properties, biscuits.

Introduction

The banana (*Musa paradisiaca*) grows best in a humid tropical environment with an optimum temperature 27˚C during the day and minimum temperature is not below 13˚C[1]. India is the world's largest producer of banana with 13.90 million tons followed by Uganda (10.14 million tons). Within the country, banana ranks first in the production and third in area (after mango and citrus fruits) among the fruit crops. Occupying about 13% of the total area under fruits in India, banana is grown almost in every state. Among the states, area under banana is the highest in Tamil Nadu (92,200 hectares) followed by Maharashtra (72,200 hectares). Productivity of banana is the highest in Maharashtra at 60 metric tons per hectare followed by Tamil Nadu at 52.70 metric tons per hectare. All India average is 34.30 metric tons per hectare[2]

Banana blossom is a nutritional edible flower present in the tip of the banana plant. It is a rich source of nutrients and antioxidants which have several health benefits. The juice from the male bud provides an apparent remedy for stomach problems in people of all ages. For strengthening babies, vitamin rich nectar sap can be taken from the banana blossom buds[3]. Although banana blossom having a tremendous nutritional value, it's an easily perishable food. One of the best preservation methods for vegetables is dehydration to increase the shelf life and preserve the nutrients. Sri Lankan people consumed this blossom as a curry mixed with rice and wheat bread[4]. Dietary fibre is very important to maintain our body health, to reduce the cholesterol level and protect our body from obesity. Banana blossom contains abundant dietary fibre (5.74g/100g). According to the

American Dietetic Association, except for some therapeutic situation, dietary fibre can be consumed through the food. The recommended intake of dietary fibre is 2-35g/day for a healthy adult[5,6]. In previous studies, banana flowers are good source of antioxidants including phenolics and flavonoids[7]. Antioxidants are very important in the enhancing of human resistant in many diseases. The chloroform, water, and ethanol extract of *Musa sapientum* flowers were found to exhibit hypoglycaemic activity in alloxan diabetic rat[8,9].

Nowadays, the intake of banana blossom is very low in the metropolitan cities. Because of the technical world, the preparation of banana blossom dish is really little bit tough. If we make any ready to eat food items means everyone can consume it easily. The objective of the present study was to analyze and compare the effect of pre-treatment on dehydrated banana blossom with natural antioxidants between citric acid and rinsed rice water. And Study the functional properties, physicochemical properties and Antioxidant properties like Radical scavenging assay and total phenol content by DPPH (2, 2-diphenyl-1-picrylhydrazyl) method and Folin's reagent of the banana blossom powder. And the third one was the incorporation of this different pre-treated blossom powder in biscuits.

Materials and Methods

Sample preparation

This experiment was conducted in the Food analysis lab, National Agricultural Foundation in Taramani, Chennai. *Musa paradisiaca* is the most popular banana blossoms were collected in local area of Chennai. The bracts were removed and the sandal white blossoms were taken out and spread in filter paper for 2 minutes to remove moisture present in surface. Then cut the banana blossoms for 3mm as per the previous study and immersed in different solutions like Citric acid solution (0.2%)[4] and Rinsed rice water solution for 1hour. Citric acid solution and rinsed rice water are natural antioxidants. The formation of brown pigments is developed when PPO (poly phenol oxidase enzyme) reacts with phenolic compounds. This enzyme generates o-quinones, which subsequently undergoes non-enzymatic oxidative polymerization leading to the development of brown pigments[10]. Therefore, to reduce this brown pigment development, a very rapid inactivation of PPO is required before PPO generates o-quinones. For these reason, rinsed rice water is used in vegetables. Mainly rinsed rice water contains vitamin B_3 (Nicotinic acid), it act as antioxidants and minimize enzymatic browning reaction occurs in vegetables. Rinsed rice water was used as filtered one for pre-treatment. The blossom which is immersed in the rinsed rice water showed good appearance and freshness after one hour when compared with blossom which is immersed in citric acid solution.

After pre-treatment, the sliced blossoms are drained and loaded in to an electric tray dryer and dried for 50˚C for 5-6 hours. We have tested with four temperatures - 40˚C, 50˚C, 60˚C, 70˚C. Among these four, 50˚C only showed the best results in drying. (60˚C and 70˚C showed charred one and 40˚C extends the time and not so good). Then the dehydrated blossoms were ground into fine powder and this powder was used for further analysis.

Chemicals and Reagents

Methanol, Gallic acid, Folin's – Ciocalteu reagent, Copper sulphate, Sodium hydroxide, Sulphuric acid, Sodium carbonate, DPPH (2, 2-diphenyl-1-picrylhydrazyl), Ammonium sulphate, Methyl indicator, Petroleum ether.

Proximate composition analysis

Banana blossoms were analyzed for nutritional composition (moisture, protein, fat, ash, and crude fibre) by AOAC method[11]. Sample was weighed into previously weighed dry moisture plate and dried in an oven at 105°C to a constant weight. Protein was determined by Nano Drop method. The A_{280} method is applicable to purified proteins exhibiting absorbance at 280 nm in a Nano Drop instrument (ND-100 Spectrophotometer). It doesn't require a standard curve and is ready for quantization of protein samples. This module displays the UV spectrum, measures the protein's absorbance at 280 nm (A_{280}) and calculates the concentration (mg/ml). Moisture free flour samples of each variety were weighed in moisture free thimbles and crude fat was extracted by refluxing with petroleum ether in a soxhlet apparatus. Total ash content was determined by igniting the samples in a muffle furnace, at 600°C, for 3-4 h. Crude fibre was estimated by acid alkali digestion method. Mineral analysis was done by atomic absorption spectrophotometer (AAS).

Functional properties

Swelling power and solubility:

1g of banana flower powder was weighed in a pre weighed 50 ml centrifuge tube and mixed with 10ml distilled water. These centrifuge tube is heated at 80˚C for 30 minutes while shaking continuously. The tube was removed from the bath, wiped dry, cooled to room temperature and centrifuged for 15 minutes at 2200 rpm. The supernatant was evaporated, and the dried residue weighed to determine the solubility. Solubility was determined using the formula:

Solubility % = (weight of dried sample in supernatant/weight of original sample) X100

Swollen sample (paste) obtained from decanting the supernatant was also weighed to determine the swelling power was calculated using the formula.

Swelling power= (weight of wet mass sediment/weight of dry matter in the gel)

Foaming capacity and stability:

2 grams of blossom powder was mixed with 50ml distilled water in a 100ml measuring cylinder. The suspension was vigorously shaken to foam. Volume of foam (ml) after mixing was expressed as the foam capacity while volume of foam at 60 minutes after shaking was used as indicator of foam stability.

Least gelation concentration:

Banana blossom powder was mixed with 5ml distilled water in test tubes to obtain suspensions of 2-20% (w/v) concentration. The test tubes were then heated for one hour in a boiling water bath, cooled rapidly under running tap water and further cooled for 2 hours in a refrigerator at 4˚C. The least gelation concentration was regarded as that concentration at which sample from the inverted test tube did not fall or slip.

Water and oil absorption capacities:

1g of blossom powder sample mixed with 10ml distilled water or oil in a pre-weighed 50ml centrifuge tube. The suspension was agitated for one hour on a shaker after which it was centrifuged for 15 minutes for 2200rpm. The separated oil was then removed with a pipette and reweighed. The water or oil absorption capacity was expressed as grams of water or oil absorbed per gram of the sample.

Bulk density:

Banana blossom powder sample was put into 25 ml measuring cylinder up to 5ml. The measuring cylinder was then tapped continuously on a table until a constant volume has obtained. Bulk density (g/m^3) was calculated using the formula:

Bulk density= (weight of the sample/volume of sample after tapping) (g/ml or g/cm^3)

Emulsification capacity:

2g blossom powder and 23 ml of distilled water were mixed for 30sec using a magnetic stirrer at 10 Ruhrer speed. After complete dispersion, refined vegetable oil was added continuously from a burette and blending continuously at room temperature until the emulsion break point was reached, when there was separation into 2 layers Emulsification capacity was also determined in the pH range (1-12) and the values are expressed as millimeters of oil emulsified by 1g flour.

Physico-chemical properties

pH values:

Ten grams of the blossom powder was shaken with 100ml water, allowed to stand for 30 minutes. The solution was filtered and the pH of filtrate was measured in pH meter.

Colour Analysis:

The instrumental measurement of banana blossom powder and biscuits was carried out with a colour analyzer HUNTER LAB. The measurements were performed through a 6.4mm diameter diaphragm with an

optical glass, placing the flour directly on the glass. The parameters determined were L^* (L^*= 0 [blank] and L^*= 100[white], a^* (-a*=greenness and +a*= redness) and b (-b*= blueness and +b^*=yellowness).

Anti-oxidant properties

Total phenol content:

The total phenol content of extracts was determined by the Folin- Ciocalteau colorimetric method. An aliquot of (1ml) extracts or standard solution of Gallic acid (20, 40, 60, 80 and 100 mg/l) was added to 25ml volumetric flask, containing 9ml of distilled water. Reagent blank using distilled water was prepared. 1ml of Folin- Ciocalteau's phenol reagent was added to the mixture and shaken. After 5 minutes, 10ml of 7% Na_2CO_3 solution was added to the mixture. The solution was diluted to the volume (25ml) with water and mixed. After incubation for 90 minutes at room temperature, the absorbance against prepared reagent blank was determined at 750 nm at Spectrophotometer. Total phenolic content of banana blossom powder was expressed as mg gallic acid equivalents (GAE) /100g.

Free radical scavenging activity

DPPH radical scavenging was monitored with suitable method[7]. Various concentrations of flower extracts (1ml) were mixed with 4ml of 70% methanol solution containing DPPH radicals (40µg/ml). The mixture was shaken vigorously and left to stand for 15 minutes in the dark. The reduction of the DPPH radical was determined by reading the absorbance at 517nm. The radical –scavenging activity was calculated as percentage of DPPH discoloration, using the equation.

$$\% \text{ RSA} = [(A_{control} - A_s)] / A_{control}] \times 100$$

Where, $A_{control}$ is the absorbance of the control (solution to which no antioxidant was added) and A_s is the absorbance of the extract solution. The extract concentration providing 50% of the free radical scavenging activity was calculated from the graph of radical scavenging activity percentage against extract concentration.

Biscuit preparation

Biscuit preparation idea was obtained from literature reviews. But novelty of this biscuit lies in the addition of ingredients and composition (Table 1). We tried banana blossom biscuit with various concentration of blossom powder (1%-6%) for 50 gram. Dough was not so good in 1 to 4 percent and 6 percent showed dark colour. 5% percent showed good appearance.

Table 1. Composition of banana blossom biscuit

Ingredients	Weight (grams)
Wheat	23g
Corn	12
Banana blossom powder	2.5 (5%)
Maida	15
Sodium carbonate	0.3
Sugar	15
Salt	0.5
Edible oil	12

Statistical analysis

Triplicate analyses were conducted for each sample. The experimental data were expressed as ± standard deviations of three separate determinations.

Figure.1 Biscuit-standard

Figure.2 Biscuit-control

Figure.3 Biscuit- PRRW

Figure.4 PCAS biscuits

3. Results and Discussions

Proximate analysis of Banana blossom

The samples of banana blossoms powder were analyzed for proximate composition (moisture, protein, fat, ash, and crude fiber) following the standard methods published by Association of Official Analytical Chemists[12].

In the nutritional values, Moisture value for the powdered samples (10%) highly decreased when compared to fresh sample (contain 89% moisture). Blossom powder incorporated biscuits containing 3% moisture.

Dried powder contains higher ash percent (3.5%) than the fresh one (2%). But the powder incorporated biscuit contains 1.5%.

The Crude fat value of the powdered sample contains the 0.6%. These values are closely related to fresh sample fat value. The fat values in biscuits were slightly increased to 1% except PCAS (0.7%). Oil absorption is slightly reduced in PCAS than other two. Five fatty acid were identified in banana blossom, they are palmitic, stearic, oleic acid, linoleic and α-linolenic acids which are lower the risk of cardiovascular diseases[13].

In powdered samples, PCAS contain high protein content when compare to control and PRRW. In biscuits PRRW contain high protein content when compare to control biscuit and standard one. These results may due to the stable protein present even after baking.

Crude fibre content in powdered samples is almost similar 16%. But blossom powder incorporated biscuits contain high fibre (20%) when compared with standard and control biscuits.

Functional Properties

Foaming capacity and stability:

The foam capacity and stability of three (control blossom powder -which was not pretreated, Pre treated with rinsed rice water (PRRW), Pre treated with citric acid solution (PCAS) has been presented in clear way. In control the foam capacity is reduced from 7ml to 1ml but the foams are dispersed in between the samples for 17ml and in PRRW foam capacity are reduced from 8ml to 1ml, here also the foams are dispersed in between the samples. In PCAS, foam capacity reduced from 7ml to 1ml, here foam dispersion in between the samples for 12ml. Normally forms are used to improve the texture, consistency and appearance of foods. Foam

formation and stability are dependent on pH, surface tension and processing methods. Foam stability is important since the usefulness of whipping agents depend on their ability to maintain the whip as long as possible. Since the flours have poor foam capacity and stability they might be poor foaming agents in foods requiring foam ability but the dispersed foam in between the sample it will helps to retain the whip as long as possible. Here the foaming capacity is better in control sample.

Table: 2 Nutritional composition of banana flower powder and biscuits

Sample	Moisture (%)	Ash (%)	Crude fat (%)	Crude protein(µg/µl)	Crude fiber (%)
Control- powder	10	3.5	0.6	267	16
PCAS powder	10	3.5	0.6	291	16
PRRW powder	10	3.5	0.6	270	16
Control biscuits	3	1.5	1	146	20
PCAS biscuits	3	1.5	0.7	167.9	20
PRRW biscuits	3	1.5	1	171.6	20

Table: 3 Functional properties of banana blossom powder

Sample	Bulk density (g/ml)	Water absorption capacity (g/g)	Oil absorption capacity (g/g)	Foam capacity (ml)	Solubility (%)	Swelling power
Control	0.69	5.80	7.14	7	14.21	1.142
PRRW	0.61	4.75	7.48	8	13.9	1.042
PCAS	0.63	5.42	7.27	7	16.53	1.02

Figure .5 Radical scavenging activity for control blossom powder

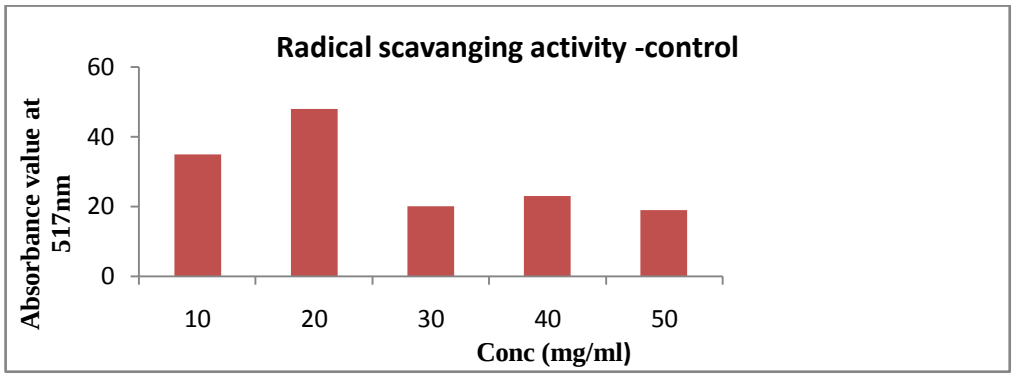


Figure.6 Radical scavenging activity for PRRW blossom powder

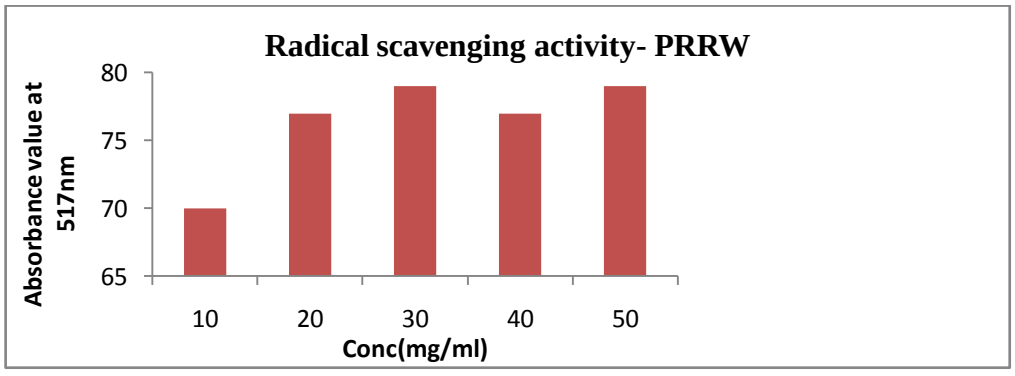
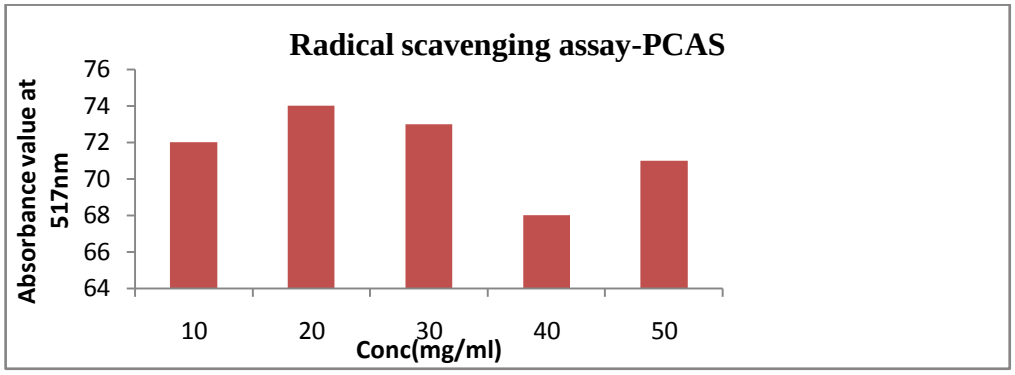


Figure.7 Radical scavenging activity for PCAS blossom powder



Least gelation concentration:

Gelation is an aggregation of denatured molecules. The least gelation concentration of control banana blossom powder was 0.9 (W/V) while the PCAS powder was 0.6 (W/V) and PRRW powder was 0.9 (W/V). Here the control and PRRW powder increased the least gelation concentration. The ability of protein to form gels and provide structural matrix for holding water, flavors, sugars and food ingredients is useful in food applications. The results show that the PCAS powder would be a good gel forming or firming agents, and would be useful in food system such as biscuits and snacks which require thickening and gelling.

Solubility:

The solubility value of the banana blossom powder is in PCAS- 16.53%, PRRW-13.9% and control-14.21%. There is no significance difference between Control and PRRW. According to the authors solubility of flour is an indicator of its quality. The high solubility (16.53%) of PCAS suggests it is digestible and therefore could be infant food formulation.

Swelling power:

The swelling power values of banana blossom powder ranged between control (1.142), PRRW (1.042) and PCAS (1.02). No difference between these 3 samples. High swelling power is an important criterion for good quality powder/flour. Here the control sample is having little bit higher swelling power than the other.

Water absorption capacity:

Water absorption capacity of flour is useful indicator of protein can be incorporated with the aqueous food formulations, especially, those involve dough handing. Interactions of protein with water, is important to properties such as hydration, swelling power, solubility, and gelation[14]. The high water absorption capacity of the powder suggests they could be useful in cookies formulation. The results showed that the water holding capacity of control sample is 580% (5.80g/g), the PCAS sample had 542% (5.42g/g) and PRRW sample had 475% (4.75g/g). Compare the three controls having the good water holding capacity.

Oil absorption capacity:

When compare with water absorption capacity, banana blossom powder sample containing high oil absorption capacity. In oil absorption capacity, Control- 714% (7.14g/g), PCAS- 727% (7.27g/g) and PRRW-748% (7.48g/g). Here there is no significant difference among these 3 samples. The lipid binding is dependent on the surface availability of hydrophobic amino acids. Oil absorption capacity is important in retain the flavor and provide soft texture to food like cakes, soups, sausages.

Bulk density:

The bulk density of the banana blossom powder for control is 0.69(g/ml) was significantly higher than the sample PCAS- 0.63 (g/ml) and PRRW- 0.61(g/ml). Bulk density is a measure of heaviness of powder and an important parameter that determines the suitability of powder for the ease of packaging and transportation of particulate foods as well as for infant formulations. The low bulk density powders/ flours are desirable in infant food preparation. The low bulk density of the blossom powder could be useful in the infant formulation.

Emulsification capacity:

The emulsification capacity of the blossom powder control is 1.35 ml, PCAS is 1.34ml and PRRW is 1.35. There is no significant difference in these three.

Physico-Chemical Properties

pH:

The pH of the control blossom powder is 6.91, PRRW is 6.84 and PCAS is 6.77. It is an especially important consideration in food preservation and storage, because of the inhibitive effect of acid on the growth of micro organisms and enzymes. Mostly the vegetables are processed at high temperature and for longer times than the more acid fruits. pH value also affects various physical properties of some foods e.g., texture, gel strength in foods.

Table: 4 Physico – chemical properties of banana blossom powder and biscuits (colour analysis)

SAMPLE	L^*	a^*	b^*
Control powder	42 ± 0.09	2.47± 0.03	5.43 ± 0.01
PCAS powder	42.67±0.11	3.23±0.03	6.87±0.06
PRRW powder	42.24±0.43	2.93±0.02	6.3±0.14
Control biscuits	43.68±0.86	5.63± 0.88	17.66±0.64
PCAS biscuits	48.06±0.80	5.415±0.531	18.56±1.07
PRRW biscuits	42.04±3.73	7.50±0.64	19.88±0.51

L^* (L^*= 0 [blank] and L^*= 100[white], a^* (-a*=greenness and +a*= redness) and b (-b*= blueness and +b^*=yellowness)

Table: 5 Mineral analyses for the banana blossom powder.

Sample	Fe	Cu	K	Ca	Mg	Na
Control	1.6	0.1	185	32	54	20.1
PRRW	5.2	1.2	663.3	543.6	270.7	350.3
PCAS	4.8	1.0	663.5	646.2	265.4	138.2

Colour analyses:

The mean L^* value for all banana blossom powder ranged between 42- 42.67 and in biscuits 42.04-48.06. This indicates that a substantial level of colour changes had occurred during drying that yielded dark brown powder[15]. In fresh blossom, the colour changes of slices during drying (browning reaction occurs). As a result it increases in reddish and yellowness tones, which correspond to increase in a^* and b^* values. The (a^*) and b^* value of PCAS is higher than the PRRW and control. The sample PRRW having high reddishness and yellowness in biscuits. This is due to moisture loss, enzymatic and non enzymatic browning.

DPPH radical scavenging assay:

DPPH is a stable organic nitrogen radical and free radical compound with a purple colour which change in to stable yellow compound in reacting with an antioxidant. The reduction capacity of DPPH was determined by the decrease in its absorbance at 517nm, which was reduced by the antioxidant. This method is mainly used to evaluate the antioxidant capacity of extracts from the plant materials. The addition of the flower extract into the DPPH solution caused a rapid decrease in absorbance at 517nm indicating the excellent scavenging capacity of the flower extracts. In this assay, control having the high radical scavenging activity in the concentration of 20%, PCAS had high RSA in 20%. But in PRRW graph showed the high percent activity in 30% and 50%.

Total phenol content:

Phenolics are plant secondary metabolites which are very important in chelating redox active metal ions, inactivating lipid free radical chains, and preventing hydro peroxide conversations into reactive oxy radicals as they have been generally recognized. In control sample, the total phenol content is 100mg/ml, in PCAS- 52mg/ml, and in PRRW- 39mg/ml. Among these 3 samples, control having the best phenol content in the banana blossom powder.

4. Conclusion

Biscuits products are sometimes used as a vehicle for incorporation of different nutritionally rich ingredients. Addition of fiber to biscuits products increases dietary fiber intake and decreases of the caloric density of baked goods. This study confirms that the percentage of fiber in biscuit is increased when compared with commercialized biscuits. PRRW shows higher protein content in biscuits and in powder. And taste is good in PRRW biscuit than other. Mineral analysis showed the good results in Na, K, Mg, Cu and Fe. The phenol content and the antioxidant activity showed the best results in 20-30%. The physic-chemical properties and functional properties of the banana blossom powder were studied in detailed manner. In future we have an idea to make bread items, biscuits for the diabetic people by adding low calorie sweetener with this blossom powder.

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