PHYSICO CHEMICAL & SENSORY EVALUATION OF NUTRITIOUS BALLS PREPARED FROM BANANA PSEUDO STEM

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ABSTRACT

Bananas are widely cultivated all over the world and their year-round availability, affordability, varietal range, taste, and nutritive and medicinal value make them the favourite fruit among all classes of people. It was reported that after harvesting 88% by weight of the banana plant produced waste in the form of banana pseudo stem or trunk and leaf and this can lead to environmental problems in banana farming regions. Banana pseudo stem can contribute to enhancing the nutritional level in animal feed as well as for human consumption and it has been reported that banana pseudo stem contains fibrous components which are rich in cellulosic material or NSP, mineral content, dietary fibres, low molecular weight sugars and antioxidant components. Nutritious balls prepared from dried banana pseudo stem powder were physically, chemically, microbiologically and sensorial examined. The proximate analyses indicated that nutritious balls showed a high amount of ash content, carbohydrates, crude fiber, protein and a low amount of crude fat. This revealed that the nutritious balls were rich in all nutrients especially dietary fibre that helps in reducing cardiovascular diseases, obesity, colon cancer and diabetes. The powder had a shelf life of 60 days, with stable water activity and moisture content in aluminium pouches as compared to the other three packaging materials. It was determined that the product had a better yield rate, with a regular length and breadth of the balls. After the microbiological, test it was observed that the nutritious balls were within safe levels, and will not affect the health of consumers, provided the powder is stored in a cool and dry place.

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1. INTRODUCTION

The banana is a tropical herb of the genus Musa and of the family Musaceae. It is known as the 'common man's fruit'. India ranks first among the banana-cultivating countries of the world with an annual production share of 25% of the total harvest (unctad.org). The common edible banana is the Musa acuminate. Bananas are widely cultivated all over the world. Banana (*Musa* sp.) is the second most important fruit crop in India next to mango. Its year-round availability, affordability, varietal range, taste, and nutritive and medicinal value make it the favourite fruit among all classes of people. It has also good export potential. Production is highest in Maharashtra (3924.1 thousand tones) followed by Tamil Nadu (3543.8 thousand tons). Within India, Maharashtra has the highest productivity of 65.70 metric tones/ha against the national average of 30.5 tones/ha. The other major banana-producing states are Karnataka, Gujarat, Andhra Pradesh and Assam (2011, Naushie exports). It is believed that the origin of the genus Musa banana plant is southeastern Asia (Constidine and Constidine, 1982). Exploring the possibilities of converting bananas into a cash crop by developing products of commercial interest is one way of solving this problem. In developed countries, 40-50% of the annual agricultural produce is converted into value-added commodities. However, in India it is less than 2 % annually. Such a situation further necessitates the development of value-added products (Surendranathan et al,2003) It was reported that after harvesting 88% by weight of the banana plant produced waste in the form of banana pseudo-stem or trunk and leaf (Elanthikkal et al., 2010) and this can lead to environmental problems to banana farming regions. Banana pseudo stem can contribute to enhancing the nutritional level in animal feed as well as for human consumption. Banana pseudo stem (PS), which is a byproduct of banana cultivation, are good sources of dietary fibre. It is one of the various common foods in some of the regions of India. The rough and hard outer layers are removed to reveal the stark white and sometimes yellowish-green stem. Banana pseudo stem has a crisp texture and a mild flavour, both somewhat sweet and tart with a slightly bitter aftertaste and is often used in savoury curries or as fried snacks.

Biologically active compounds, such as dopamine, noradrenaline, serotonin, isochronal-4-one derivative, and ant hyperglycemic factors, have been identified in different parts of the banana plant (Pari et al.,2000; Qiam et al.,2007; waalkes et al., 2011). In our previous study we showed that PS, when fed at 5% level to diabetic rats, significantly reduce blood glucose levels and ameliorate the diabetic condition (Jamuna et al.,2011). Beneficial effects of pseudo stem on hyperglycemia and advanced glycation end products in streptotocin-induced diabetic rats (Raganna S.,1997). It has also been reported that banana pseudo stem contains fibrous components which are rich in cellulosic material or NSP, mineral content, dietary fibres, low molecular weight sugars and antioxidant components (Abdul Aziz et al., 2011; Cordeiro et al., 2004; Mukhopadhyay et al., 2008). Consumers with diabetes are benefit by using pseudo stem because they contain bioactive compounds that can promote glucose uptake into cells. Banana pseudo stem is rich in total dietary fibre 28.8±0.9% which includes soluble dietary fiber and insoluble dietary fiber 1.4±0.0 and 27.4±1.1% respectively. Starch content is about 27.3±1.1%, protein (2.5±0.0%), fat (1.7±0.0), free sugar (3.4±0.1), ash (0.3±0.0) and moisture (0.3±0.0). (Bhaskar et al.,2011).

PS is consumed as vegetables in many countries. In traditional forms of medicine such as Ayurveda, PS is used for the management of various diseases including diabetes (Pellai et al.,1995). Conversion of the pseudo stem into flour can increase the shelf of the product and partially substituting snack balls with banana pseudo stem flour can increase the uptake of dietary fibres into consumers' diets. Dietary fibre is made up of carbohydrate polymers derived from plants; it consists of 10 or more monomeric units that are resistant to hydrolysis by the endogenous enzymes in the small intestine of humans with complete fermentation in the colon which can promote beneficial micro fauna growth (Fuentes-Zaragoza et al.,2010). Different food products like pakoras, bread, cookies, and other bakery products and snack balls which are incorporated with banana pseudo stem flour can be prepared.

The recommended allowance of DF is 35-40 g/day for an adult and should be taken in small amounts but at regular intervals. In habitual Indian diets, being based predominantly on unrefined cereals and plant foods, this level of DF intake is easily achieved (Joshi et al.,1991). Modernization has increased the demand and intake of canned, packaged, and ready-to-eat food products. There is an increasing trend towards replacing traditionally cooked foods with readily available processed foods. Consumers are now aware that they are deprived of some food components, which may be of immense importance to health. Different processing methods like milling of grain to obtain refined flour, canning of fruits, and vegetables, etc.,

curtail the supply of fibre from the diet (Niness., 1999; Thomson., 2005).

A high level of fibre intake has health-protective effects and disease-reversal benefits. The fibre intake is lower in women and is much less in the low-income group and tribal populations in our country. Persons who consume generous amounts of DF, compared to those who have minimal fibre intake, are at lower risk for developing chronic heart diseases, stroke, hypertension, diabetes, obesity, and certain gastrointestinal diseases (Juntunen et al.,2003; Andherson et al.,2003). Increasing the intake of high-fibre foods or fiber supplements improves serum lipoprotein values, lowers blood pressure, improves blood glucose control for diabetic individuals, aids weight loss, and promotes regular bowel movement by undergoing fermentation in the large bowel, producing short-chain fatty acids, which are implicated to exert a protective effect against the development of colon cancer thus prevents constipation, removes toxic waste from the body and prevents microbes from stagnating(Annison., 1994; Gonil et al., 1996; Haralahampu., 2000). Considering these benefits of dietary fibre in our diet, use of banana pseudo stem which is a good source of dietary fiber as well as antioxidants and other vitamins and minerals to the potato balls shows promising improvement in the nutritive value of the final product. Therefore, this research project was designed for preparation, standardization and physicochemical studies of the nutritious balls. Moreover, it is a snack which is prepared from plant waste sources i.e. banana pseudo stem flour and is rich in dietary fibre. Partially substituting banana pseudo-stem flour with other flour in nutritious balls has the potential to increase dietary fibre intake.

The main objective of this project was to prepare banana pseudo stem powder for nutritious balls and standardization of method for preparation of the nutritious balls. After preparation conduct a shelf-life study of the prepared powder by using different packaging materials and comparing water activity and moisture content of the sample on different days, followed by microbiological analyses and proximate analyses of the prepared powder and conduct a sensory evaluation of the nutritious balls by semi-trained panellists.

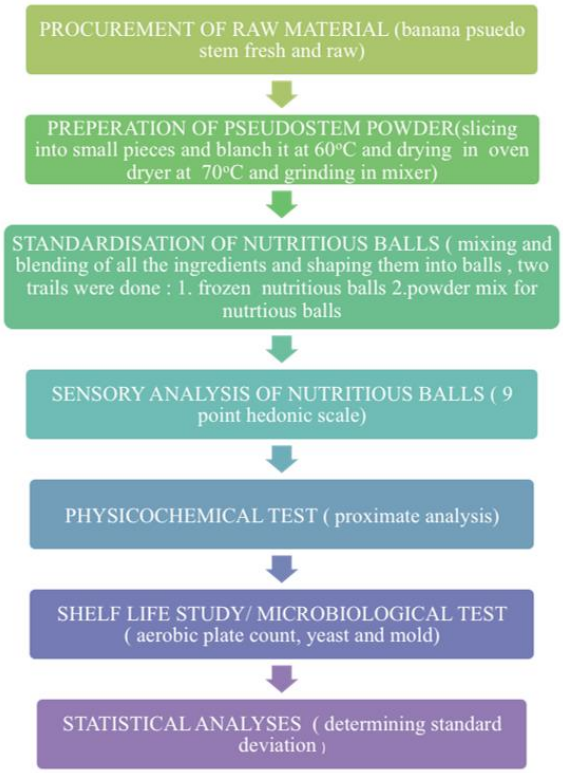
In storage studies of bread prepared by incorporating banana pseudo-stem flour and composite breads containing hydrocolloids by Ho et al., 2014, it was observed that bread incorporated with banana pseudo-stem flour at 100g/kg level and the same composition added with hydrocolloids at 8g/kg (based on flour basis), i.e. xanthan gum or sodium carboxyl-methyl cellulose were determined for moisture, water activity, texture, thermal and microbiological quality during storage (3 days). Results indicated that all the formulated bread crusts showed an increase in moisture and water activity during storage, but vice versa for the respective bread crumb. All the formulated breads showed an ultimate trend in hardness with time. The composite bread showed higher onset and peak temperature values than the control white bread. Control had higher gelatinization enthalpy change temperature than composite bread. Microorganisms count was also increasing with storage time.

In physicochemical characteristics and sensory evaluation of wheat bread partially substituted with banana pseudo stem flour by Ho et al., 2013 showed that composite bread had higher moisture, ash, crude fibre, soluble, insoluble and total dietary fibre contents but lower protein, fat and carbohydrate contents than control. Bread incorporated with banana pseudo stem powder resulted in lower volume, darker crumb and lighter crust colour than the control. All bread containing banana pseudo stem powder had greater total phenolic, and antioxidant properties than the control bread.

2. OBJECTIVES

- To prepare banana pseudo-stem powder
- Preparation and standardization of nutritious balls out of the powder
- To study the physiochemical, sensory and microbiological studies of nutritious balls

2. METHODOLOGY



3.1. PROCUREMENT OF RAW MATERIAL

The Banana pseudo stem was bought from a retail shop. Musa acuminates and Musa balbisiana are the two varieties available in the Indian market. Musa acuminate was the variety which was used the for production of the banana pseudo stem powder.

3.12. PROCESSING OF PSEUDO-STEM POWDER

Banana pseudo-stem flour will be prepared by peeling of the epidermis of the pseudo stem manually and then cut into small pieces using a sterile knife. Then rinse it with RO water. The cut pieces have to be boiled for 10min in boiling water and water is drained off.

The boiled sample are then dried in a tray dryer (GMP model- double walled) at 70°c for 16 h and then blend in a mixer (Preethi blue leaf gold, 750W-MG 150). The blended samples are sieved in sever to separate the larger particles (sieve shaker 75-200mm).

3.13. PREPARATION OF NUTRITIOUS BALLS TRIAL 1

INGREDIENTS REQUIRED

TABLE 1: INGREDIENTS USED FOR TRIAL 1

INGREDIENTS	BRAND NAME	QUANTITY
Boiled potato mash	Normal vegetable market	101.7g
Corn flour	Brown & Polson corn flour	10g
Banana stem powder	Musa acuminate	7g
Rice powder	Double horse rice powder	7.5g
Salt	Tata salt	2.05g
Pepper	Reliance pepper	0.5g
Red chili powder	Everest tikkalal	0.31g

- Take raw potatoes and boil them in a pressure cooker for one whistle
- Mash the potatoes with a masher
- Add banana pseudo-stem powder, rice powder and corn flour into the mashed potatoes
- Mix all the ingredients thoroughly and uniformly
- Add salt, pepper and red chili powder to the dough evenly
- Make small balls out of this dough of same size
- Keep the balls in a zip ouch(42 micron PET+PE) and freeze them in refrigerator (-18°c)

TRIAL 2

TABLE2: INGREDIENTS USED FOR TRIAL 2

INGREDIENTS	BRANDNAME	QUANTITY
Potato powder	Vegit aloo mash	101.7g
Corn flour	Brown & Polson corn flour	10g
Banana stem powder	Musa acuminate	7g
Rice powder	Double horse rice powder	7.5g
Salt	Tata salt	2.05g
Pepper	Reliance pepper	0.5g
Red chili powder	Everest tikkalal	0.31g

3.14. SENSORY EVALUATION:

To determine the overall acceptability of the nutritious balls 10-panel members (semi-trained), mainly students from department of Food Technology, are to be used to evaluate on the basis of 9 point hedonic scale (Lazaridou, Duta, Papageorgiou, Belc and Biliaderis,2007; Sabanis, Lebesi and Tzia,2009).

3.15. PHYSICO-CHEMICAL ANALYSIS:

3.151. PROXIMATE ANALYSIS

Moisture, crude protein, crude fat and ash content of the sample will be determined by standard procedures used by the association of Official Analytical Chemists (1990, 1995). The total carbohydrate content of the banana pseudo stem powder will be determined by difference, subtracting the % of crude fat, moisture, crude protein, and ash from 100%. Moisture content measurements were done in duplicate. The measurement of crude fat and crude protein was done in triplicate.

MOISTURE CONTENT (AOAC method 977.11)

Into a flat bottom metallic dish, spread a thin layer of finely divided asbestos (Gooch grade). Dry at 110^{o}c for 1 hour; cover the dish, cool and weigh. Spread 20g of sample uniformly over the asbestos layer. Weigh as quickly as possible to avoid loss of moisture. Remove the cover and dry in a hot air oven at atmospheric pressure. Maintain a temperature of 70oc in case of fruits or their products, or 100^{o}c in the case of vegetables or their products. The duration of heating will vary with the type of tissues; 16-18 hours are sufficient for most tissues. After drying replace the lid, cool the sample in a desiccator, and reweigh. Repeat the sample, if necessary, until the consecutive weighing does not vary by more than 3-5 mg. Tissues or products which contain volatile organic constituents or high percentages of sugars cannot be brought to a constant weight. In such cases, a compromise procedure must be adopted. A standard technique should be employed. Drying at 55oc for 4 days is generally suitable. The sample after determination of moisture content could be used for estimation of ether extractives. If the dried sample is to be used for ashing and estimation of minerals, dry in a silica dish without any filter (asbestos) aid.

CRUDE FAT (AOAC method960.39)

Transfer the dried sample remaining after moisture determination to a thimble and plug the top of the thimble with a wad of fat-free cotton. Drop the thimble into the fat extraction tube of sox let apparatus. Pour approximately 75ml or more of anhydrous ether through the sample in the tube into the flask. Attach the top of fat extraction tube to the condenser. Extract the sample for 16 hour or longer on water bath. The water bath should be regulated so that the ether which volatilizes condenses and drops continuously upon the sample without any appreciable loss. At the end of the extraction period, remove the thimble from the apparatus and distill off most of the ether by allowing it to collect in the sox let tube. Pour off the ether when the tube is nearly full. When ether has reached a small volume, pour it into a small, dry, beaker through a small funnel containing a plug of cotton. Rinse the flask and filter thoroughly, using several small portions of ether. Evaporate the ether on a steam bath at low heat, preferably under a current of air. Dry at 100oc for 1 hour, cool and weigh. The difference in the eights gives the ether-soluble material present in the sample.

ASH CONTENT (AOAC method 923.03)

Note the tare weight of three silica dishes (7-8cm diameter). Weigh 5-10 g (or more if minerals are to be estimated) of the sample into each. If moist, dry on a water bath (after determination of moisture content) the same dishes may be used for ashing. Ignite the dish and the contents on a Bunsen burner. Ash the material, at no more than 525^{o}c for 4 to 6 hours; if need be, ash overnight in a muffle furnace. Cool the dishes and weigh. The difference in weights gives the total ash content and is expressed as percentage.

3.16. SHELF-LIFE STUDY

Shelf-life study of the powdered sample was done using four different packaging materials. Materials were: glass jar, PVC pouches, freezer bag (polyethene), plastic laminated aluminium pouches. The sample was kept in above-mentioned packaging materials for a period of 45 days and water activity and moisture content of samples was taken at an interval of 0 day, 7 days, 15 days, 30 days and 45 days.

TABLE3: PACKAGING MATERIAL AND THICKNESS

PACKAGING MATERIALS	THICKNESS
PVC POUCHES	0.06 mm
FREEZER BAGS	0.05 mm
PLASTIC LAMINATED ALUMINIUM POUCHES	0.13 mm
GLASS JAR	-

3.17. MICROBIOLOGICAL ANALYSIS

Enumeration of microorganisms using SPCA (standard plate count agar) method:

- Take 1 gram of the sample and make up the volume of the sample to 100ml, mark it as the stock solution.
- Dilute the stock solution to 10-6 and 10-8 serial dilutions
- Take 0.1ml of the 10-6 and 10-8 using micropipette and pour it on the separate petri plates and pour molten agar medium on it
- Gently rotate the plate for spreading uniformly
- Incubate it at 37oc and check for the growth after 24-48 hours

Enumeration of yeast and mold:

- Take 1 gram of the sample and make up the volume up to 100ml and mark it as stock solution
- Dilute the stock solution to 10-6 and 10-8 serial solutions
- Take 0.1ml of the 10-6 and 10-8 using micropipette and pour molten agar on the solutions in the plate separately
- Add 10% tartaric acid in the medium
- Incubate it at 37oc and check for the growth after 24-48 hours

4. RESULTS AND DISCUSSIONS

4.1. NUTRITIVE VALUE OF PSEUDO STEM BALLS

TABLE4: NUTRITIVE VALUE OF PSEUDO STEM BALLS

NUTRIENTS	VALUE PER 100g
Protein	4.51g
Mineral	1.01g
Crude fiber	6.15g
Carbohydrate	49.26g
Energy	257.58 kcal
Calcium	19.175g
Iron	1.24g
Fat	2.24

The nutritional labeling of the nutritious pseudo stem balls was done using nutritive value of Indian foods by Gopalan. It was seen that the product contained highest amount of energy i.e. 257.58 kcal/100g and carbohydrate of 49.26g. According to the research conducted, the carbohydrate content in banana pseudo stem was 57.58% (Abdul Aziz et al., 2011).

Moreover, the final product had a mineral content i.e. calcium and iron of 19.175g and 1.24g respectively. It was reported that ash content in banana pseudo stem was 3.03% (Abdul Aziz et al., 2011; Zanoni & Peri, 1993). In addition, the high ash content of banana pseudo stem has an abduntant mineral composition, as previously reported by several researchers (Cordeiro et al., 2004 and mukhopadhyay et al., 2008). Overall the product had a good nutritive value.

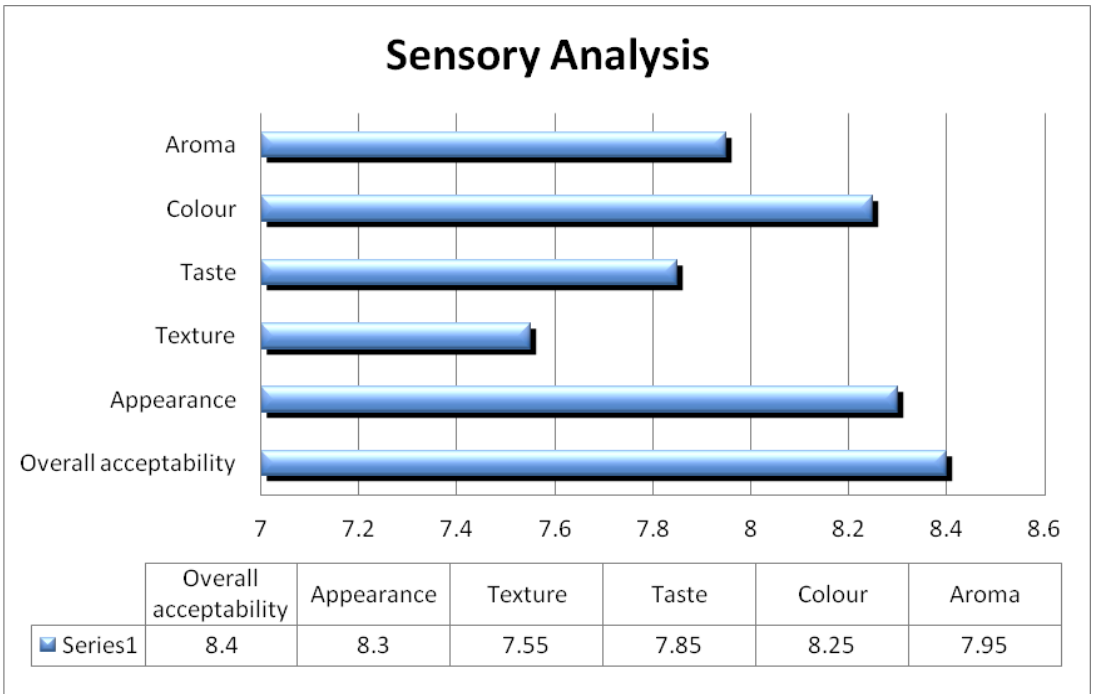
Previous research shows that banana pseudo stem contains 4.63% protein (Abdul Aziz et al.,2011; Zanoni 7 Peri, 1993) but after nutritional labeling it was concluded that banana pseudo stem had 4.51% protein content per 100 gram of serving. Nutritious balls exhibited a lower fat content as compared to other food samples. According to Mellema (2003), the fat uptake is largely affected by the moisture content of the food, where water molecules are an important substance in the formation of the barrier. Hence, the available moisture can reduce oil penetration into food.

There is an increase in the crude fiber content in nutritious balls i.e. 6.15g, as stem fiber naturally contain a significant percentage of fibers, such as cellulose, hemicellulose and lignified vascular tissues. The previous research reports that banana pseudo stem contains 19.51-29.92% crude fibre (Abdul Aziz et al., 2011).

4.2. SENSORY ANALYSIS

TABLE5: SENSORY ANALYSES OF NUTRITIOUS BALLS

PARAMETERS	MEAN±STANDARD DEVIATION
APPEARANCE	8.3± 0.48
TEXTURE	7.55± 0.76
TASTE	7.85± 0.57
COLOR	8.25± 0.79
AROMA	7.95± 0.68
OVERALL ACCEPTABILITY	8.4± 0.51



The sensory scores for colour, aroma, appearance, texture, taste and overall acceptability of nutritious balls were obtained from semi-trained panellists. The texture of the nutritious balls exhibited the lowest scores. This may be because of the hardness of the outer covering. The product was overall acceptable because the product received a score greater than 5. The panelists rated highest score for appearance of the product.

4.3. PHYSICAL PARAMETERS

TABLE6: PHYSICAL PARAMETERS OF NUTRITIOUS BALLS

PARAMETERS	READINGS
LENGTH	4.14 ± 0.05
BREADTH	2.1± 0.1
YIELD	50 g = 9 balls

Physical parameters of the product basically the length and the breadth were done by using measuring ruler. It was identified that the product had a dimension of 4.14cmX2.1cm. Considering the yield of the sample, from 50 grams of mixture we can obtain approximately 9 nutritious balls which is a good yield and cost wise too.

4.4. PROXIMATE ANALYSIS

TABLE7: PROXIMATE VALUE OF POWDER

ASH CONTENT	20.16%
CRUDE FAT	2.8%
PROTEIN	1.89%
FAT ABSORPTION	3.3%
MOISTURE CONTENT	9.1%
WATER ACTIVITY	0.35
TOTAL CARBOHYDRATE	60.58

After conducting proximate tests of the prepared powder, it was observed that the crude fat was coming out to be 2.8% moreover fat content also decreases with 10% banana pseudo stem and this is what attributed to the high moisture content and low fat uptake (Lee- Hoon et al.,2013), and fat uptake is largely effected by moisture content of the food, where water molecules are an important substance in the formation of a barrier. Hence available moisture can reduce oil penetration into food.

The protein content in the powder was unable to detect because of the technical default in the

Kjeldahl machine. Previous research has reported that banana pseudo stem contains 4.63% protein (Abdul Aziz et al.,2011).

Crude fiber could not be determined because of shortage of chemicals and time. Incorporation of banana pseudo stem can increase the amount of crude fiber in the final product because stem fibers contain significant percentage of fibers, such as cellulose, hemicellulose and lignified vascular tissues. The previous research report shows that banana pseudo stem contains 19.51-29.92% crude fiber (Abdul Aziz et al., 2011).

After analysis moisture content of the powder was 9.1%. The substitution of banana pseudo stem powder into the flour increased the moisture content. This was because of the higher water absorption capacities due to the hydrophilic chains in the dietary fiber of banana pseudo stem has higher water absorption capacities.

Water activity is an important factor in determining the shelf life of the product. According to Rosell, Rojas and Benedito de Barber (2001), hydrocolloids express higher water holding capacity. The changes in water activity were found to be parallel to changes in moisture content. The water activity in powder was 0.35.

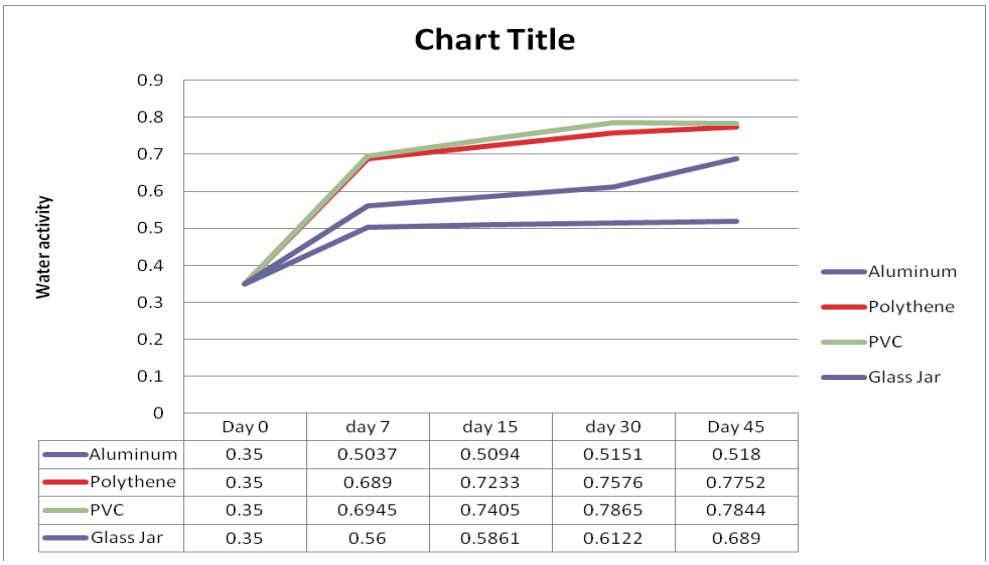
It was reported that ash content in banana pseudo stem was 3.03% (Abdul Aziz et al., 2011; Zanoni & Peri, 1993).In addition the high ash content of the sample i.e. 20.16% can be correlated with the presence of a high mineral content. The banana pseudo stem has an abundant mineral composition as previously reported by several researchers (Cordeiro et al., 2004 and Mukhopadhyay et al., 2008).

4.5. SHELF-LIFE STUDIES

TABLE8: SHELF-LIFE STUDY OF POWDER

GROWTH CHAMBER CONDITIONS (Relative humidity= 90%, Temperature=37ºC)

PACKAGING MATERIALS	WATER ACTIVITY	MOISTURE CONTENT (%)
DAY 0	(Temp=25ºC)	
• ALUMINIUM POUCHES	• 0.35	• 9.1%
• POLYETHYLENE BAG	• 0.35	• 9.1%
• PVC POUCHES	• 0.35	• 9.1%
• GLASS JAR	• 0.35	• 9.1%
DAY 7	(Temp=25ºC)	
• ALUMINIUM POUCHES	• 0.5037	• 9.165%
• POLYETHYLENE BAGS	• 0.689	• 12.68 %
• PVC POUCHES	• 0.6945	• 12.95 %
• GLASS JAR	• 0.56	• 9.21%
DAY 15	(Temp=26ºC)	
• ALUMINIUM POUCHES	• 0.5094	• 9.1975 %
• POLYEHTYLENE BAGS	• 0.7405	• 13%
• PVC POUCHES	• 0.7405	• 13.75 %
• GLASS JAR	• 0.5861	• 9.3%
DAY 30	(Temp=26ºC)	
• ALUMINIUM POUCHES	• 0.5151	• 9.23%
• POLYETHYLENE BAGS	• 0.7576	• 16.90%
• PVC POUCHES	• 0.7865	• 18.37%
• GLASS JAR	• 0.6122	• 9.5%
DAY 45	(Temp=26ºC)	
• ALUMINIUM POUCHES	• 0.518	• 9.5%
• POLYETHYLENE BAGS	• 0.7752	• 16.88%
• PVC POUCHES	• 0.7844	• 20.64 %
• GLASS JAR	• 0.689	• 10.53%



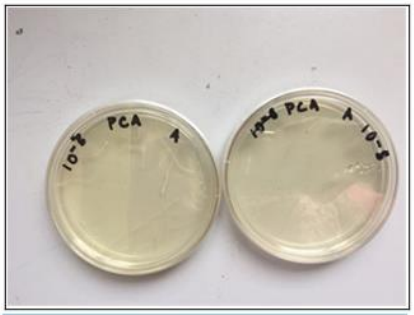
	Day 0	day 7	day 15	day 30	Day 45
Aluminum	0.35	0.5037	0.5094	0.5151	0.518
Polythene	0.35	0.689	0.7233	0.7576	0.7752
PVC	0.35	0.6945	0.7405	0.7865	0.7844
Glass Jar	0.35	0.56	0.5861	0.6122	0.689

Banana pseudo stem powder was kept in four different packaging materials i.e. aluminum pouches, polyethylene pouches, PVC pouches and glass in growth chamber at 90% RH and 37oC for accelerated shelf life study (ACL) . It was interpreted that on zero day a_w was 0.35 in all packaging materials. On 7th day aw was least in aluminum pouches i.e. 0.5037, followed by glass jar, polyethylene bags and PVC pouches. The absolute limit for the growth of microorganisms is water activity of 0.61, which applies to certain molds. Foods with water activities below 0.61 will not support the growth of microorganisms and any spoilage that occurs is chemical rather than microbiological (John Garbut, essentials of food microbiology). On day 15th water activity in aluminum pouches was stable i. e 0.509 and in case of glass jar it was 0.5861. On the other hand, in PVC pouches and polyethylene pouches water activity increased to 0.7405 and 0.7405 respectively and is not at all acceptable for food productions, because in a_w of 0.8-0.61 growth of mycotoxigenic molds is seen and the toxin production is highest between 0.93-0.98 (essentials of food microbiology, John Garbut). Taking the case of 30th day, we could see that water activity in case of aluminum pouches was 0.51 and in case of glass jar it had an increase to 0.6122 which is not acceptable (Reason as mentioned above). On 45th day, the water activity was stable in case of aluminum pouches i.e. 0.51. This concludes that aluminum pouches gave best results for shelf-life study and this packaging material can be used for storage purpose of the powder for better shelf of the product.

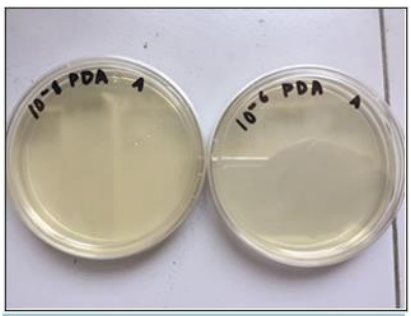
4.6. MICROBIOLOGICAL ANALYSIS

TABLE9: MICROBIOLOGICAL COUNT OF POWDER

SHELF LIFE	DILUTIONS	NO. OF COLONIES (MEAN)	NO. OF VIABLE ORGANISMS
PDA	10^{-5}	3	$30x10^5$
	10^{-7}	1	$10x10^7$
PCA	10^{-5}	20	$200x10^5$
	10^{-7}	12	$120x10^7$



STANDARD PLATE COUNT



YEAST AND MOLD PLATE COUNT

Banana pseudo stem powder is having a longer shelf life as compared to other food products. The powder not only loses its freshness in terms of its dryness and aroma with time, but also is consequently subjected to bacteria, mold and yeast spoilage (Baik & Chinachoti, 2010). Furthermore, the food products can be re-contaminated with microorganisms after baking, during cooling, and packaging (Jay, Loessner, & Golden, 2005; Lainez et al., 2008).

Results from APC and yeast and mold plate count indicated that the nutritious balls were within safe levels, and will not affect health provided the powder is stored in a cool and dry place (to avoid microbial contamination).

5. SUMMARY AND CONCLUSION

The substitution of banana pseudo stem improved the nutritional characteristics of the nutritious balls and is rich in dietary fiber and other vitamins and minerals. This product ensures a high level of dietary fiber intake which is important for our customers and is having a disease-reversal effect. A person consuming a high level of dietary fibre in his/her daily diet has a reduced risk of developing chronic heart disease, stroke, hypertension, diabetes, obesity and certain gastrointestinal problems. It is also suggested beneficial in the management of diabetes and obesity and colon cancer. Physical analysis indicated that we can get a better yield of nutritious balls from pseudo stem powder. The final product was overall acceptable by the semi-trained panellists and the appearance of the product scored highest. It was interpreted after proximate analyses that, the product contained a good amount of ash content which showed that banana pseudo stem powder was rich in mineral content. Because of the water-holding capacity of the banana pseudo stems very less amount of crude fat was present. Aluminium pouches were suitable for storage of the powder and they kept the water activity under control during shelf-life studies as compared to the other three packaging materials. The banana pseudo stem is convenient to use as it is in powdered form and can be stored in a dry and cool place for longer shelf life as compared to the raw banana pseudo stem which is having high amount of water content and therefore can't be stored for more than 2-3 days. Microbiological analyses of the nutritious balls showed that the product analyses were within safe levels, and will not affect health provided the powder is stored in a cool and dry place.

6. FUTURE RECOMMENDATIONS

Banana pseudo stem is widely available in huge quantity, as most of the parts of the banana plant after harvesting is wasted, we should use every part of the plant judiciously. As mentioned above the banana pseudo stem is rich in several nutrients like dietary fibre which helps in reducing cardiovascular diseases, obesity, diabetes, and colon cancer. If other facilities are available further studies can be conducted on banana pseudo stem powder. This can be incorporated in different food products like chapattis, bakery products and other snack products, increasing its nutritional value. Further tests like texture analyses of the product using texture analyzer, color of the product using Minolta spectrophotometer can be done. Drying of the banana pseudo stem can also be done solar cookers, saving energy. Therefore, cost of the production can be reduced further as compared to method used in the research project.

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