ORIGINAL ARTICLE

Development of an Edible and Biodegradable Tableware Using Fruit Wastes - An Alternative to Plastic Tableware

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ABSTRACT The use of plastics has become an indispensable part of our everyday lives and also it has proven to be detrimental to the environment and the health of all living organisms. Researchers around the world have been trying to resolve this ever-increasing issue of waste generation. Edible tableware has thereby gained massive importance as a viable alternative to plastics. The current work focuses on the usage of biodegradable fruit wastes as raw materials in formulating edible tableware prototypes thereby aiding in waste management. Pineapple core, pomegranate peel and orange peel, all bearing high nutritive value were powdered and used in the formulation. Jackfruit seed powder was used as a natural binder and flax seed flour was used to enhance the efficiency of the binder. The characterization studies of the obtained prototypes showed substantial amounts of protein and significantly low amounts of crude fiber and fat in them. Ash content was significantly high in all the variations. Variable amounts of moisture were observed in different variations. Tests for microbial contamination showed absence of *E. coli* and heavy metals like lead and mercury below the permissible level. Other various attributes of the prototype like appearance, colour, texture, odor, flavor, palatability, etc., were found to be satisfactory to the panel. Thus, it was concluded that the obtained prototypes can be used as an effective substitute to plastic tableware.

Keywords: Edible tableware, Flax seed flour, Jackfruit seed powder, Pineapple core powder, Pomegranate peel powder, Waste management.

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INTRODUCTION

Plastic products have always been in demand due to their convenience and economic efficiency but it is a matter of great concern that it increases the generation of non-degradable wastes drastically. To combat this, researchers and entrepreneurs have developed innovative edible and biodegradable tableware or cutlery using bio-based raw materials.[1] But its applications are limited to special markets with environmental considerations as the price of bio-based materials are very high.[2] Thus, in this context, the use of cheap, by-products of underutilized food process is a promising strategy for producing cheaper edible cutlery.

Food wastes and its by-products are of great importance due to the presence of proteins, lipids, starch, micronutrients, bioactive compounds, dietary fibres with moisture and ash content. These factors determine their nutrition level, shelf life, microbial stability, mineral content and ultimately their overall quality. The total sensory characteristics of fruits, like flavor, texture is given by fat content. So edible tableware or coated films based on these plant materials can act as an alternative means of nutrient intake, including pigments and polyphenols with antioxidant capacity. [3,4]

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In this regard, the current work attempts to utilize fruit waste such as pineapple core, pomegranate and citrus peels into a dough using jack fruit seed flour as natural biodegradable binder and flax seed flour as binding enhancer, to make edible cutlery like spoons and bowls that are equivalent to multivitamin tablets. The products obtained were further characterized by determining their proximate composition.

MATERIALS AND METHODS

Source of Raw Materials

Pineapples, oranges and pomegranate were procured from a local vendor in Bengaluru. Jackfruit seed powder and flax seed flour were purchased from a local store. The raw materials were processed for further use.

Processing of Raw Materials

Pineapple core powder: Pineapple cores were separated from pineapples using corer and were cut into small pieces. The pieces were placed on the trays of the dehydrator set to 55°C for approximately 20 hours. The dehydrated pieces were then powdered, sieved and refrigerated for further use.[5]

Pomegranate peel powder: The pomegranate peels were cut into pieces were treated with 2% salt solution for 10 minutes, drained and washed again with clean water, air dried to remove surface water. The peels were then dried in an oven at 65°C and crushed into a powder and sieved. It was bottled and stored for further use.[6]

Orange peel powder: Cut orange peels were sun dried, powdered and sieved. Powder was stored for further use.[7]

Preparation of Binders

Jackfruit seed flour: The jackfruit seeds were dried in the oven to remove moisture. They were then peeled and powdered.[8]

Flax seed flour: The flax seeds were ground into powder and sieved.[9]

Dough preparation and moulding: Pineapple core powder, jackfruit seed flour and flax seed flour were used as ingredients in three variations (V_1, V_2 and V_3). Orange peel and pomegranate peel powder were used as flavor additives in variation V_2 and V_3 respectively to enhance the taste. Sweeteners such as jaggery and salt were added to all the variations. A dough was prepared using warm water and then shaped in different tableware moulds greased with vegetable oil. All the variations were baked in a hot air oven at 120°C overnight.

Composition of Variation 1 (V_1):110g of pineapple core powder was mixed with 8g of jackfruit seed flour and 50g of flax seed flour.

Composition of Variation 2 (V_2): 26g of pineapple core powder was mixed with 8g of jackfruit seed flour and 47gms of flax seed flour. To this 22g of orange peel powder was added for flavor.

Composition of Variation 3 (V_3): 26g of pineapple core powder was mixed with 8g of jackfruit seed flour and 40gms of flax seed flour. To this 33g of pomegranate peel powder was added for flavor.

Proximate Analysis

The proximate analysis of the developed tableware for the determination of moisture, ash, protein, fat, total carbohydrates and crude fiber were based on Official Methods of Analysis. The proximate analysis tests were performed in duplicates for all the three variations.

Determination of Moisture Content

2g of the sample was taken into a pre-weighed china dish. The dish was then placed in a hot air oven at 110°C for 1 hour. The dish was cooled in a desiccator and weighed.[10] Moisture percent by weight was then calculated using the formula ;

$$\text{Moisture}\% = (W_1 - W_2)/(W_1 - W) * 100$$

Where, W- weight in grams of the empty dish.

W_1-weight in grams of the dish with the sample before drying.

W_2-weight in grams of the dish with the sample after drying.

Determination of Ash Content

1 g of the sample was taken in a pre-weighed silica crucible. The crucible was placed in a muffle furnace at 600°C for 1 hour. It was then cooled in a desiccator and weighed. [10] Ash content was determined using the formula;

$$\text{Ash}\% = (W_2 - W_3)/(W_2 - W_1) * 100$$

Where, W_1- weight in grams of the empty dish

W_2- weight in grams of the dish and the sample

W_3- weight in grams of the dish and ash

Determination of Fat/Lipid Content

1g of the sample was homogenized well using 20ml of hexane: isopropanol mixture (10:10) and subsequently filtered through a fat free filter paper. The filtrate was collected in a separating funnel, mixed and shaken well and was kept undisturbed overnight. The formed inorganic layer is drained to a pre-weighed empty container. The difference in weights is measured to determine the fat content. [11]

$$\text{Lipid content} = W_2 - W_1$$

Where, W_2- weight of the dried container after lipid extraction (grams)

W_1-weight of empty container (grams)

Difference=lipid content present in the sample.

Determination of Crude Fibre Content

To 0.5 g of the sample taken in a beaker, 5 ml of 1.26% dil.H_2SO_4 was added and refluxed for 15mins. The mixture was filtered and to the filtrate 5ml of 1.26% NaOH solution was added and refluxed further for 15mins. The mixture was filtered again and the filtrate washed with ethanol and refluxed for 15mins. It was filtered again and allowed to dry for 15mins. The residue obtained equivalent to fibre content was weighed.[10]

Estimation of Protein Content

The protein content of the sample was estimated against 0.2 to 1 ml aliquots of standard solution of Bovine Serum Albumin (BSA). 1ml of the given unknown sample was pipetted into another test tube. The volume in each tube was made up to 1ml with distilled water. 1ml of distilled water was pipetted out into another test tube which served as the blank. 3ml of Biuret reagent was added to all the tubes. The contents of each tube were mixed by vertexing and incubated at 37°C for 10minutes. The contents were cooled to room temperature and the absorbance was read at 540nm against the blank. [12]

Tests for Microbial and Heavy Metal Contamination

The samples were tested for microbial contamination; fecal coliforms [13], *E. coli* [14], total plate count [13] and heavy metal contamination; lead [15], mercury. [16]

Sensory Evaluation

The sensory evaluation of the developed tableware was done using 16-member panelists who assessed seven attributes of each variation such as acceptability, taste, flavor, texture and overall acceptability. [17]

STATISTICAL ANALYSIS

Average of the trials were expressed as average ± standard deviation (SD). These were considered for plotting graphs using Microsoft Excel, version 16.0.13901.20198. For sensory evaluation, average of each attribute was calculated and a radar graph was plotted for the obtained values using Microsoft Excel, version 16.0.13901.20198.

RESULTS AND DISCUSSION

Processing of Raw Materials

The pineapple core powder was subjected to dehydration and the obtained powder was sieved to a finer texture and stored in a refrigerator for further use.

Dough Preparation, Molding and Final Product

Different variations (V_1, V_2 & V_3) were casted into different molds and dried under dry heat in oven (Figure 1). The developed products were dried in a desiccator and sealed in airtight pouches for further analysis (Figure 2).

Proximate Analysis

Table 1 represents the result of proximate analysis of all three variations developed prototypes (V_1, V_2, V_3). This analysis encompassed the moisture, ash, protein, fat and crude fiber

Figure 1: Dough Preparation And Molding Using Three Variations (V_1, V_2, V_3)

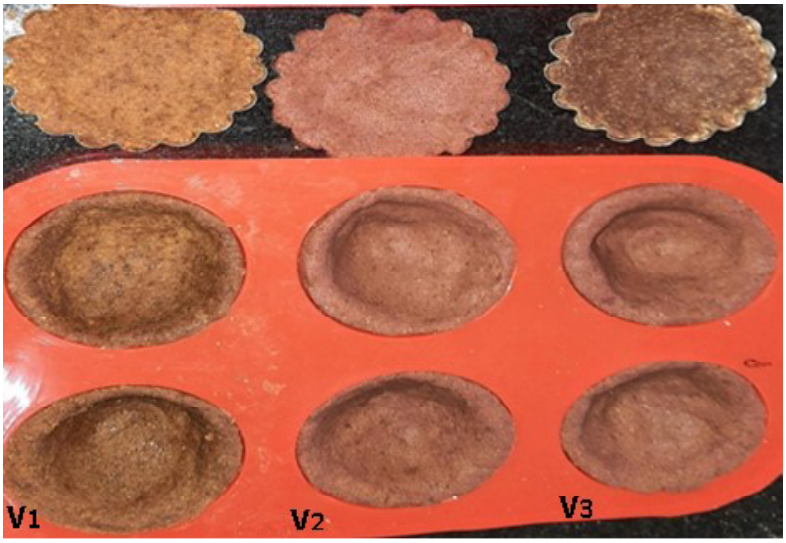


Figure 2: Final Products Of Edible Tableware Of Different Shapes Were Developed Using Three Variations (V_1, V_2, V_3)

Table 1: Results of Proximate Analysis of different variations (V_1, V_2, V_3)

Parameters tested	V_1	V_2	V_3
Moisture content (%)	1.25±0.02	0.75±0.01	7±0.01
Ash content (%)	22.5±0.03	25±0.02	28±0.03
Fat content (g)	0.27±0.02	0.195±0.02	0.19±0.04
Crude fibre content (g)	0.07±0.01	0.095±0.03	0.055±0.04
Protein content (mg/ml)	3.525±0.07	3.3±0.12	2.8±0.04

Note: * Results are expressed as mean ± SD, n=3.

content of them. Proximate analysis is important for determination of product quality, texture, mouthfeel, shelf life and microbial stability and can be used for nutritional labeling.

Determination of Moisture Content

It was observed that there was a significant difference in the moisture content in prototypes. The moisture content of V_3 was high when compared to V_1 and V_2 [Table1]. These results are nearly in accordance with those found by Rowayshed et.al., (2013). [18] The pomegranate peel powder has high water holding capacity and this property might have contributed to high moisture content in V_3.

Determination of Ash Content

Ash content in V_1, V_2, V_3 was estimated which is a measure of inorganic residues present. The percent ash evaluates the physico-chemical aspects of the edible samples. It was found that V_3 had the highest amount of ash whereas V_1 and V_2 had relatively lesser amount of ash [Table 1]. The pomegranate peel is considered a good source of ash, crude fiber and carbohydrates.[18]

Determination of Fat Content:

All the variations, V_1, V_2 and V_3 were assessed for their fat content which helps to understand the physico-chemical parameters of the edible tableware prototypes (Mouth feel, flavor and appearance). As depicted in Table 1, it was observed that V_1 had the highest fat, while both V_2 and V_3 had comparatively less amounts of fat (Table 1). Pineapple is considered to have high amounts of fat.[19]

Determination of Crude Fiber

Assessment of crude fiber in V_1, V_2 and V_3 as shown in Table 1 showed that V_2 had the highest amount of crude fiber followed by V_1 and finally V_3. Crude fiber is an estimate

of the insoluble carbohydrates present in a food sample. The high crude fiber content in V_2 was possibly due to orange peel [Table 1]. Orange peel powder has a significantly high amount of crude fiber.[7] The pomegranate peel powder is considered a good source of crude fiber.[18] The results derived in present work are in agreement with the above findings.

Determination of Protein Content

Protein content in all the edible prototypes, V_1, V_2, V_3 was estimated which revealed approximately equal amounts of protein in V_1, V_2 and V_3. Protein content estimation must be determined in food samples which reveal its role in diet and health [Table 1]. The level of protein in the core of a pineapple is found to be high which is in agreement with the results obtained.[20] From the above findings, it can be inferred that V_1 has higher nutritive value, followed by V_2 and finally V_3.

Sensory Evaluation of Different Variations

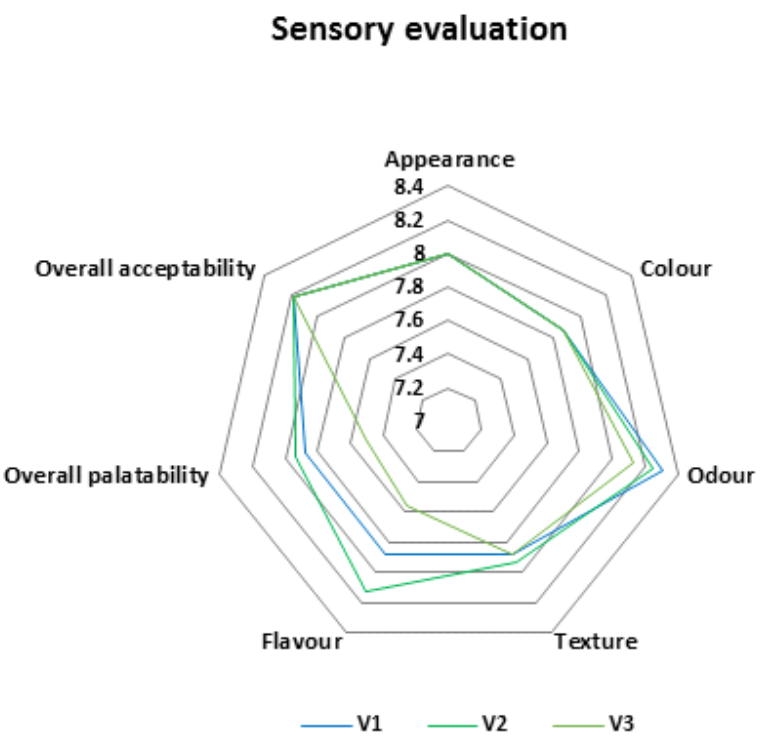
Sensory evaluation was performed for all three variations (V_1, V_2, V_3) of edible tableware which assessed various attributes such as appearance, color, odor, texture, flavor, overall palatability, overall acceptability. A panel of 16 members evaluated these attributes based on 9 – point Hedonic scale. As per the feedback provided by the panelists, V_1 and V_3 were more acceptable when compared to V_2. The feedback of sensory evaluation done by a 16-membered panel revealed that V_1 is more acceptable when compared to other two variations (Figure 3).

CONCLUSION

From an application-oriented point of view, and in order to improve performance of edible tableware, the present work attempts to analyze the use of natural, biodegradable polymer extracted from fruit waste as blends along with natural binders into edible cutlery. The project worked towards redesigning the whole product cycle as there is a need to leverage every opportunity to reduce, reuse/recycle, compost disposables.

As per the findings of the research work, the pineapple variation (V_1) was the best in terms of overall appeal. It exhibited minimal moisture content and the highest protein content as well. The pomegranate variation (V_3) also rated high in terms of ash content and crude fiber content. Future work in this field can be carried out by focusing on improving the processing of the fruit waste to achieve a more durable product. Various other fruit wastes too can be incorporated into making edible tableware with low-cost binders such as jackfruit seed powder and flax seed powder. Other alternatives can also be tested for use such as chia seeds, psyllium husk, tapioca flour. The concept of edible tableware using fruit waste as the key ingredient may be a relatively new one, an initiative which can benefit both humanity and the environment at large.

Figure 3: Sensory Evaluation of Different Variations (V_1, V_2, V_3)



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