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Effect of Finger Millet (*Eleusine coracana*) Flour and Maize Flour on Nutritional, Texture and Physico-chemical Qualities of Edible Dessert Cup

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ABSTRACT

Background: The concept of edible tableware is a recent area of development to address the alarming situation that the excessive generation of non-recyclable plastic wastes has created. Non-biodegradable plastics are a major threat to the environment. The demand for green alternatives are increasing, the edible tableware is a new concept in which the utensils like plates, bowls and spoons are eaten along with the meal.

Methods: Various composite flours can be used for making edible dessert cups. Finger millet, one of the nutritious and commonly available millets can be utilised for the development of edible dessert cup effectively. Hence, the present study was carried out to formulate healthy and environment friendly edible dessert cups. Finger millet flour was used in varying proportions ranging from 90 to 40 per cent along with 10 to 60 per cent maize flour. The best treatment was selected through organoleptic evaluation and textural properties.

Result: Among various combinations 50 per cent finger millet flour and 50 per cent maize flour was found to be better than other combinations with respect to organoleptic and textural properties. The selected edible dessert cup was subjected to physico-chemical analysis and observed to have pH (5.32), water absorption index (4.44%), water solubility index (8.56%) and oil absorption capacity (1.20%). The selected edible dessert cup was subjected to proximate analysis and observed to have moisture (3.46%), energy (406.39 Kcal), carbohydrate (83.31 g 100 g^{-1}), protein (9.31 g 100 g^{-1}), fat (3.99 g 100 g^{-1}), crude fibre (1.95 g 100 g-1), starch (50.62 g 100 g-1) and total ash (1.44 g 100 g^{-1}). Biodegradable tablewares plays vital role in green marketing for sustainable environment.

Key words: Edible dessert cup, Finger millet flour, Maize flour, Physico-chemical analysis.

INTRODUCTION

Plastic cutlery has become an important part of our daily routine in our busy schedules from morning till night. Plastics are widely used in the food packaging sector due to its attributes including longevity, strong mechanical qualities and resistance to oil, chemicals and low manufacturing costs. Earthenware, wood and glass pots have been used for thousands of years ago and over the last two hundred years. Metals including steel have been used for storing and preserving foods. Plastics have become available for use in the food industry only over the last century. Food packaging sector is the major user of plastics. Petroleum based plastics such as polyethylene, polypropylene *etc*., have replaced traditional packaging materials such as metallic cans, glass containers, paper boards, bamboo, dry leaves of some perennial trees *etc*. The demand for food packages and containers is increasing over the past few decades. The sale of plastic tablewares is growing at a rate of 30 per cent per year. Most of the street shops and public eating places use substandard plastics and thermoform plates for serving foods. With increased use of plastics having various carcinogenic, toxic and harmful chemicals which we eat, drink or use and with increased cases of cancer, dermatological, cardiovascular and other diseases, it is very important to keep ourselves fit and avoid the use or contact of such harmful contaminants in what we eat, drink or use (Poonia and Yadav, 2017). Edible tableware is trending way to overcome all these problems caused by plastic food packages and other unhealthy packaging materials (Gaspar and Braga, 2023).

Edible tableware is a new concept in which the utensils like plates, bowls and spoons are eaten along with the meal. Even if they are not consumed, they are able to degrade in the outside environment as they do not need

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any specific conditions for degradation. Edible cutlery is a natural and biodegradable commodity which can be concocted to be nutritious and replace the usage of plastic cutlery (Mukherjee and Raju, 2023). Edible cutlery is a solution that provides the same convenience as disposable forks, spoons, chopsticks and bowls without causing environment problems. Edible tableware promotes a cleaner tomorrow and it is tasty, healthy and convenient too. Biodegradable films and tablewares are prepared by using biological materials such as starch, proteins of animal and vegetable origin, fat, resins, polysaccharides, proteins and their derivatives, which are renewable and natural (Tanwar and Modgil, 2012). Edible cutlery is an upcoming line of plant based utensils that are completely safe to eat and are considered as a boon to the ecosystem. These edible cutleries are a perfect alternative to harmful plastic cutlery, they are not only safe for the environment but are also enriched with nutritious ingredients (Ghosh, 2016).

Edible dessert cups are designed as ready to eat products. Edible tableware can be used as utensils, solid and semisolids things can be served in it. The textural properties and water retention capacity are the important parameters to measure the strength of edible dessert cups. These are environment friendly as they can easily discarded and eaten by animals. Since we always throw the plastic cutlery after its use, edible cutlery can just dissolve in the soil as it is made of food grains. Every food sector service can use it to make the environment cleaner. The product is aimed to enhance the lives of the people by eliminating the need and use of plastic cutleries and protecting the ecosystem. It can be made from edible ingredients such as rice, wheat, millets, vegetables and tubers.

Finger millet (*Eleusine coracana*) has tremendous, underexplored health promoting properties when compared to other conventional cereals. Finger millet grains are easy to digest, low in glycemic index and bioactive properties (Olagunju *et al*., 2022).

One of the most widely grown cereals worldwide is maize, along with wheat and rice. However, compared to flours made from wheat, maize flour is less frequently used in baked goods made from grain (Paesani *et al*., 2021). Corn flour also has vast potential application in the bakery industry for the development of gluten free baked products like composite bread, crackers and biscuits (Sun *et al*., 2019). Bran and germ are removed during the milling of maize, although semolina or flours can be produced. However, both bran and germ have intriguing nutritional qualities.

It is pertinent to mention that scanty data is available on the standardised protocols for the production of edible tableware using commonly available and cost effective food resources. Hence the study is proposed to develop healthy and environment friendly edible dessert cups.

Objectives

- Standardisation of edible dessert cups using finger millet flour and maize flour.
- To evaluate nutritional and organoleptic qualities of developed dessert cups.

MATERIALS AND METHODS

The edible dessert cups were formulated by using finger millet flour and maize flour as the major ingredient. Finger millet, maize flour and all other raw ingredients needed for the study were purchased from the local market.

Formulation of edible dessert cups

Finger millet flour was used in varying proportions ranging from 90 to 40 per cent along with 10 to 60 per cent maize flour. Preparation of finger millet flour was depicted in Fig 1. The collected finger millet grains were cleaned, washed and soaked by following the standard procedure by Nefale and Mashau (2018) respectively. The finger millet was soaked for 8 hour in cold water at room temperature. After soaking, the finger millet grains were dried using a cabinet drier, powdered and sieved to get a uniform flour.



Fig 1: Preparation of finger millet (*Eleusine coracana*) flour.

The flours were blended well and then a dough were prepared using water and oil.

Table 1 depicts the experimental design of the variations for the preparation of finger millet flour based edible dessert cups.

Thick dough was prepared by uniformly blending the raw materials and was sheeted by dough rolling pin. Then, sheets were cut into a specific shape by dough moulders and were placed on a tray and subjected to baking in a conventional oven for 90 min at 180°C temperature, as depicted in Fig 2.

Organoleptic evaluation

A series of acceptability trails were carried out using simple triangle test at the laboratory level and selected a panel of fifteen judges between the age group of 18-35 years as suggested by Jellinek (1985). The organoleptic evaluation of the edible dessert cups were carried out using a 9 point hedonic scale for each quality parameter *viz*., colour, appearance, texture, flavour, taste and overall acceptability was recorded.

Texture analysis of edible dessert cups

Edible dessert cups were analyzed for their textural profile (hardness) through TA TX2 Texture Analyser (Stable Micro Systems Ltd., UK) equipped with a 5 mm diameter cylindrical probe was used for the analysis. The settings for tests were 500 N load cell, pre test speed of 2 mm/s, test speed of 1 mm/s, post test speed of 2 mm/s. Each sample was subjected to compression test and the texture was indicated by the first maximum peak force in the force-distance curve.

Physico-chemical properties

The pH value of edible dessert cup was determined using a pH meter (Methrohm AG, Herisau, Switzerland). The pH of the products were measured using food grade pH meter. The solution for reading pH was prepared in a ratio of 1:10 (Berwal *et al*., 2004). Water absorption index (WAI) and water soluble index (WSI) were determined by the method of Anderson *et al*. (1969). Oil absorption capacity (OAC) was determined by standard procedure of Ranganna (1986). WAI, WSI and OAC were calculated by the expressions,

$$WAI = \frac{\text{Weight of the sediment}}{\text{Weight of the dry solids}}$$

$$WSI = \frac{\text{Weight of the dissolved solids in suppernatant}}{\text{Weight of the dry solids}}$$

OAC = Initial volume of oil added to the sample - Volume of the supernatant

Proximate composition determination

Proximate composition of selected edible dessert cup (moisture, crude protein, crude fatand crude ash contents) was analysed as per the recommended AOAC (1990) methods. Carbohydrate content was calculated by subtracting the weight of moisture, crude protein, crude fatand ash contents from total sample weight. Energy value of edible dessert cup (kcal/100 g) was calculated on the basis of their caloric value which consists of caloric coefficients corresponding to the contents of proteins, carbohydrates and fats according to the formula:

Caloric value kcal/100 =

$$(\text{g protein} \times 4) + (\text{g fat} \times 9) + (\text{g carbohydrates} \times 4)$$

Cost of production

The cost of production of the most acceptable combination of finger millet flour based edible dessert cups were computed based on the market price of procured ingredients used for preparation of products along with labour charge, fuel charge, electricity charge and packaging cost. The cost was calculated for 100 g of the product and compared with similar products available in the market.

Statistical analysis

The scores obtained for organoleptic evaluation were evaluated by Kendall's Coefficient of Concordance (W).

RESULTS AND DISCUSSION

Organoleptic evaluation

Sensory evaluation is the expression of an individual like or dislikes for a product as a result of biological variation in man and what people perceive as appropriate sensory properties. It is a unique source of product information not easily obtained by other means (Iwe, 2003). Sensory evaluation is used to measure, analyse and interpret how sensory attributes of a product are perceived by people. These sensory attributes are the combination of characteristics that together produce a sensory experience (texture, aroma, colour, flavour) and the human senses like sight, hearing, taste, smell and touch are used to measure the attributes.

The suitability of finger millet flour in combination with maize flour for the development of edible dessert cups were assessed. All the prepared edible dessert cups were

Table 1: Different levels of finger millet flour and maize flour for development of edible dessert cups.

Ingredients (%)	Variations					
	FT_1	FT_2	FT_3	FT_4	FT_5	FT_6
Finger millet flour	90	80	70	60	50	40
Maize flour	10	20	30	40	50	60
Water (ml)	70	70	85	85	90	90
Oil (ml)	5	5	5	5	5	5
Guar gum (g)	3	3	3	3	3	3

organoleptically evaluated by the panel of selected judges. The mean score obtained for the organoleptic qualities of each treatment were statistically analyzed using Kendall's coefficient of concordance and the mean scores were worked out. The mean scores and mean rank score obtained by the finger millet flour based edible dessert cups were explained in Table 2. Kendall's value shows that there was significant agreement between the judges at 1% level.

The finger millet flour incorporated edible dessert cups were standardised with different proportions of finger millet flour and maize flour (Fig 3).

In the present study, the mean score for the appearance of edible dessert cups prepared with finger millet flour and maize flour varied from 8.40 (FT_1) to 8.73 (FT_5) with mean rank scores in the range of 3.23 to 3.83. Among different treatments tried for the preparation of finger millet flour based edible dessert cups, the highest mean scores of 8.73 for appearance was noticed in FT_5 and the lowest in FT_1 (8.40).

The highest mean score for colour (8.73) was noticed in FT_1, FT_2 and FT_5 and the lowest mean score for colour was observed in FT_1 (8.51). The mean rank scores of various treatments ranged between 3.23 and 3.63. The mean score for flavour of edible dessert cups based on finger millet flour was 8.20 to 8.27 with the maximum in FT_5 (8.02) followed by FT_4 (8.24), FT_3 (8.20), FT_2 (8.20), FT_1 (8.20) and FT_6 (8.20).

The mean score for the texture of edible dessert cups prepared with finger millet flour and maize flour varied from 8.67 to 8.87 with mean rank scores in the range of 3.43 to 3.70. Among different treatments tried for the preparation of finger millet based edible dessert cups, the highest mean scores (8.87) for texture was noticed in FT_5 and the lowest was FT_3 and FT_4 (8.67).

The mean score for taste of different edible dessert cups prepared with finger millet flour and maize flour ranged from 8.32 (FT_1) to 8.73 (FT_5). The treatments FT_6, FT_3, FT_4 and FT_2 obtained mean scores of 8.67, 8.47, 8.47 and 8.35 respectively. Among the different treatments, the highest

Table 2: Mean scores for organoleptic evaluation of finger millet flour based edible dessert cups.

Parameters	FT_1	FT_2	FT_3	FT_4	FT_5	FT_6	Kendall's value
Appearance	8.40 (3.17)	8.60 (3.47)	8.67 (3.63)	8.67 (3.63)	8.73 (3.83)	8.57 (3.27)	0.095**
Colour	8.73 (3.63)	8.73 (3.63)	8.58 (3.43)	8.51 (3.23)	8.73 (3.63)	8.64 (3.43)	0.067**
Flavour	8.20 (3.43)	8.20 (3.43)	8.20 (3.43)	8.24 (3.63)	8.27 (3.63)	8.20 (3.43)	0.053**
Texture	8.69 (3.50)	8.73 (3.53)	8.67 (3.43)	8.67 (3.43)	8.87 (3.70)	8.73 (3.53)	0.029**
Taste	8.32 (3.20)	8.35 (3.30)	8.47 (3.17)	8.47 (3.33)	8.73 (4.27)	8.67 (3.73)	0.139**
Overall acceptability	8.41 (2.60)	8.59 (3.13)	8.62 (3.37)	8.67 (3.77)	8.71 (4.50)	8.64 (3.63)	0.282**
Total score	50.75	51.20	51.21	51.23	52.04	51.45	

Values in parentheses is mean rank score based on Kendall's W.

**Significant at 1% level.

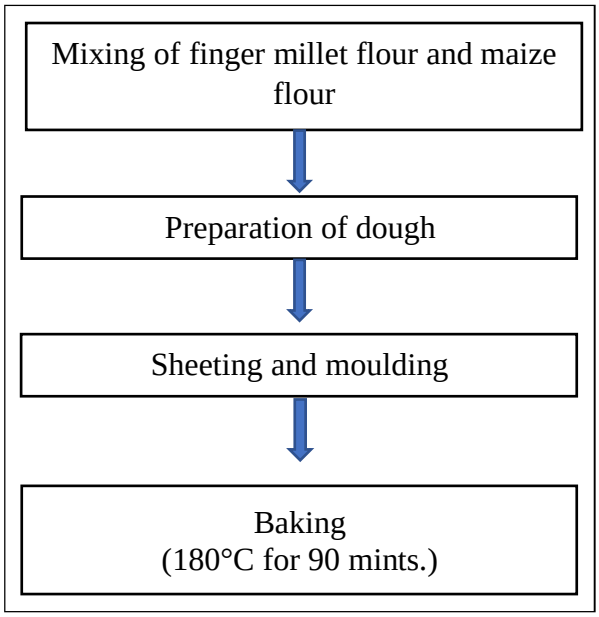


Fig 2: Flowchart for the preparation of finger millet flour based edible dessert cup.

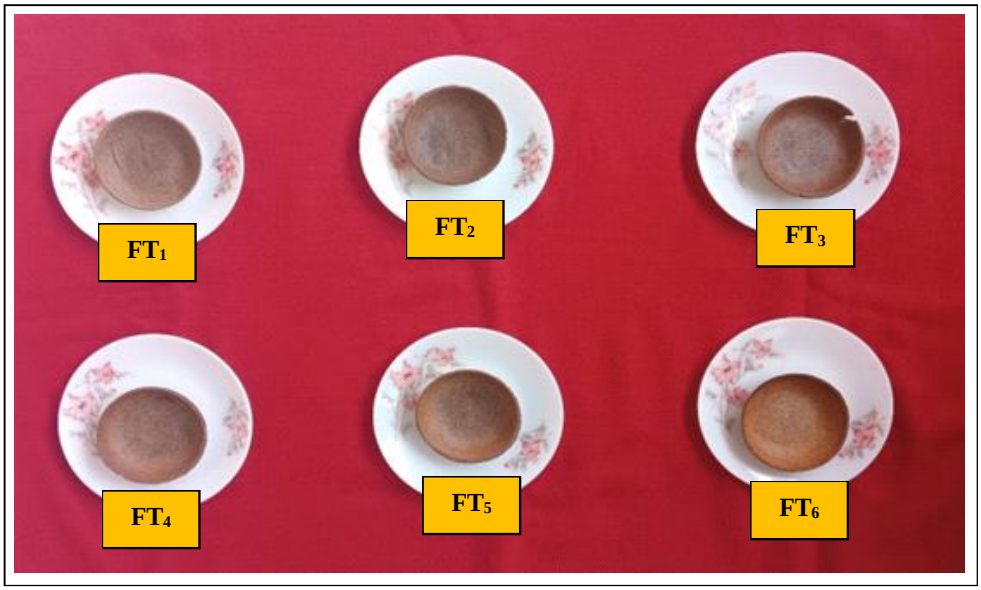


Fig 3: Finger millet flour based edible dessert cups.

Table 3: Textural property (hardness) finger millet flour based edible dessert cups.

Treatments	Hardness (N)
Control (wheat flour)	98.707[a]
FT_1	45.407[f]
FT_2	51.909[e]
FT_3	55.877[d]
FT_4	59.341[c]
FT_5	68.689[b]
FT_6	68.691[b]

Results shown as mean of three replications (n= 3) for each sample. Significantly different (*P<0.05) as assessed by Duncan's multiple range test.

mean score of 8.71 (4.50) for overall acceptability was noticed in FT5 prepared with 50% finger millet flour with 50% maize flour. The lowest mean score (8.41) with mean ranking score of 2.60 was noticed for treatment FT_1.

The mean scores and mean rank scores for sensory parameters (appearance, colour, flavour, texture, taste and overall acceptability) of finger millet flour based edible dessert cups prepared with maize flour was the highest for treatment FT_5 (50% FMF + 50% MF) than the other treatments.

The highest total score of 52.04 was noticed in FT_5 followed by 51.45 (FT_6), 51.23 (FT_4), 51.21 (FT_3), 51.20 (FT_2) and 50.75 (FT_1) respectively. The coarse nature of the finger millet flour may be affecting the appearance and texture of edible plate, if the content exceeds more than 50%. Kendall's value shows that there was significant agreement between the judges at 1% level. Stuti and Virginia (2022) formulated edible bowl using wheat flour, semolina, ragi, gram flour, orange peel powder and mosambi peel powder and it secured overall acceptability of 8.83 and for all other quality attributes like appearance, colour, flavour, texture and taste got above 8. A similar study was conducted by Sood and Deepshikha (2018), who reported that the rice flour and sorghum flour incorporated edible plate scored 7.2 for overall acceptability.

Texture analysis of edible dessert cups

The textural property of the edible dessert cups were studied using texture analyser. The hardness values for edible spoons were depicted in the Table 3. The effect of incorporation levels of wheat flour on the hardness of the edible dessert cups were analysed. The variation in the texture of the edible dessert cups may be attributed to the change in the gluten strength. As shown in table 3, the hardness of finger millet flour based edible dessert cups, peaked at 40g/100 g and 50g/100 g inclusion levels of finger millet flour respectively. The highest hardness of 98.708 N was noticed in control sample which contain 100 per cent of wheat flour, followed by 69.403 N (FT_6), 68.963 N (FT_5), 59.341 N (FT_4), 55.887 N (FT_3), 51.909 N (FT_2) and 45.407 N (FT_1) respectively. The control edible dessert cup had the best texture with highest hardness value as compared to other edible dessert cup samples. The hardness of FMF and MF incorporated edible dessert cup samples at different levels decreased from 69.403 to 45.407 N. Significant differences ($p<0.05$) in hardness has been found between control, FMF and MF incorporated edible dessert cups. The hardness of FT_5 (68.689 N) and FT_6 (68.691N) were found to be on par based on the result of DMRT. Low gluten content, binding property and hardness of finger millet is lower when compared to wheat (Wang *et al*., 2002). However, it was also observed that with increase in percentage substitution of millet flours the hardness value decreased significantly ($p<0.05$) respectively. Based on the hardness, the treatment FT_5 was selected for further studies.

Sindhu *et al*. (2023) reported that hardness for sample is 7.95 N, which contain 40 g of wheat flour, 40 g of sorghum flour, 20 g of rice flour and 2 g of guar gum.

Physico-chemical properties of selected edible dessert cup

Among various combinations 50 per cent finger millet flour and 50 per cent maize flour was found better than other combinations in respect to organoleptic properties. The selected edible dessert cup was subjected to physico-chemical analysis and observed to have pH (5.32), water absorption index (4.44%), water solubility index (8.56%) and oil absorption capacity (1.20%) and shown in Table 4. The pH is slightly similar to that found by Palamthodi *et al*. (2021) observed that the wheat flour and finger millet flour incorporated composite flour mix have pH (5.62), water absorption index (2.00%) and oil absorption capacity (2.75%). According to Premavalli *et al*. (2005) water solubility index of finger millet flour was 3.51 per cent. According to Shrestha and Srivastava, (2017) water absorption index is ability of a product to absorb water within its structural boundaries. Hazra and Sontakke (2023) reported that *Withania somnifera* root powder supplemented edible spoon have 9.70 percentage of water absorption index.

Proximate composition of selected edible dessert cup

Based on sensory evaluation, in edible dessert cups based on finger millet flour, the treatment FT_5 (50% FMF + 50% MF) was found to be the best. The nutritive value of selected finger millet flour based edible dessert cup observed to have moisture (3.46%), energy (406.39 Kcal), carbohydrate (83.31 g 100 g^{-1}), protein (9.31 g 100 g^{-1}), fat (3.99 g 100 g^{-1}), crude fibre (1.95 g 100 g-1), starch (50.62 g 100 g-1) and total ash (1.44 g 100 g^{-1}) and shown in Table 4. Sood and Deepshikha (2018) formulated edible plates using 40 g of rice flour and 40 g of sorghum flour, which contains 2.57 ,1.60, 1.72 ,4.81 and 0.64 per cent moisture, ash, crude fat, crude protein and crude fibre respectively. Sindhu *et al*. (2023) reported that edible spoon have moisture (5.32%), protein (3.85 g 100 g^{-1}), fat (1.6%) and total ash (1.38%), which contains 40 g wheat flour, 40 g sorghum flour and 20 g rice flour.

Table 4: Physico-chemical properties and proximate composition and of finger millet flour based edible dessert cup.

Parameters	FT_5 (50% FMF + 50% MF)
Moisture (%)	3.46
pH	5.32
Water absorption index (%)	4.44
Water solubility index (%)	8.56
Oil absorption capacity (%)	1.20
Energy (Kcal/100 g)	406.39
Protein (g/100 g)	9.31
Fat (g/100 g)	3.99
Carbohydrate (g/100 g)	83.31
Crude fibre (g/100 g)	1.95
Starch (g/100 g)	50.62
Total ash (g/100 g)	1.44

* FMF - Finger millet flour, MF - Maize flour.

Cost of finger millet flour based edible dessert cup

The cost of developed edibledessert cup was Rs. 20.28/ piece. The cost of commercially available edible dessert cups in the range of Rs. 20-30 per piece. The cost of prepared edible dessert cup was lower compared to the market price.

CONCLUSION

Edible dessert cup is a sustainable way for better alternative to one time use plastic cutlery. This research highlights the utilisation of finger millet flour and maize flour for the development of edible dessert cup for nutritional enrichment. The edible dessert cup developed in this study, as a sustainable alternative to single use plastic and these tablewares were nutritious that can be eaten or along with the food served. From the study it is evident that highly acceptable edible dessert cups could be prepared from finger millet flour and maize flour. Among combination of finger millet flour and maize flour, the treatment FT_5 (50% FMF+ 50% MF) was the most acceptable combination. They exhibited minimal moisture content and the highest protein content as well. Although the idea of edible cutlery is a relatively recent one, it can be advantageous for both people and the ecosystem as a whole. Biodegradable tableware is a sustainable alternative for non biodegradable tablewares and is an innovative idea for income generation.

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Authors' contributions

The idea of the topic has been postulated by Rammya Molu K. Verified and corrected by Dr. Aneena E. R. All other authors were involved in data gathering and reviewing the draft. The draft was verified by all authors.

Conflict of interest

The authors declare that there are no conflict of interest

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