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Physiochemical and Sensory Properties of Edible Cups Conceptualized from Food By-Products

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Our community today is going through multiple challenges, in the arena of nutrition and the environment. The use of plastic or paper containers to pack foods is on a huge rise proportional to the increase in the purchase of outside foods. In terms of environment, the concern is with the the improper disposal of plastics, which destroys volumes of species, causes pollution in land and water, elevates greenhouse gas emissions and contaminates the food chain, in health perspective, there is arise in the pervasiveness of various non-communicable diseases because of several carcinogenic,toxic, and hazardous chemicals present in foods we consume packed in those containers. As an alternative initiative, this study aims to formulate nutritive edible cups utilizing wheat flour as the major ingredient, and the by-products of the food industry namely rice bran, dehulled chickpea flour, groundnut cake, pomace of beetroot, apple, and molasses in different proportions, thereby providing a solution to disposal of waste products from food industry also. The edible cups formulated with different proposition of the listed ingredients were subjected to Organoleptic and functionality evaluation. The accepted variation of the edible cup was further analysed for nutritional composition and phytochemical composition. The results show that these nutritive edible cups were found to be palatable and can be utilized to serve solid and semi-solid foods and can be consumed along with the served food. The edible cups provide sufficient energy(354Kcals), carbohydrates(74.2g), fat(1.5g), protein(10.8g), fiber(4.6g), polyphenols, flavonoids, and phytochemicals.

Keywords: By- products; Edible cups; Flavonoids; Five Food groups; Polyphenols.

The unlimited use of plastics (367 metric tons in 2020) in day-to-day life is posing asubstantial peril to the global eco-system. Plastics being non-degradable pollute soil if disposed of recklessly, if incinerated pollute air, if thrown away in water bodies pollute marine ecology and the microplastics cause a serious danger to marine animals and in-turn to the humans consuming it[1]. Bisphenol A present in plastics jeopardizes the endocrine system causing hormonal imbalances, which is the reason behind many disorders[2].

Consumable cutleries and crockeries are made from natural and hazard free ingredientswhich are ensured safe for human consumption. They can be designed to provide nutrients along with eliminating the problem adjoining the usage of plastics for throwaway cutleries and crockeries. Even though, edible cutleries and crockeries are greatly unreachable to people at present, researches have confirmed the interest for such products among the masses[3].The use of edible cutlery and crockery will promise a healthy planet and healthy

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life by plummeting the health risks like cancer, endocrine disruption, and weakened immunity with revelation to oozing plastics which are commonly used to serve and store foods. As a remedy, edible plates were developed from rice flour(30g), sorghum flour(30g) and spinach extract(20g)[4], while edible spoons were formulated from wheat flour, rice flour and sorghum flour[5], and munch bowls were formulated using a mixture of wheat bran, wheat flour, and roobois tea[6]. The products were functional and acceptable. Considering these literature reviews, this study was proposed to develop consumable cups from wheat flour as a major ingredient and using byproducts from foods such as rice bran, dehulled chickpea flour, groundnut cake, pomace of beetroot, apple, and molasses, in order to reduced waste from food industry and to make wealth out of waste.This study will also serve as a means to achieve SDGs namely "Assure healthy lives and facilitate well-being for all at all ages, Take critical efforts to combat climate modification and its consequences, Good health and wellbeing, Decent work and economic growth, Industry, innovation, and infrastructure, Responsible consumption and production[7].Also, a study by Krishita et al. has recommended to experiment on edible crockeries as it may have a huge impact on the consumers nutritional status, and environment[8].

Objectives of the Study

• Formulation of consumable cups using the value-added dough prepared from by-products of foods from different food groups.

• Assess the organoleptic acceptability of developed variations of the consumable cups.

• Determine the performance attributes of developed cups.

• Determine the nutritional and phytochemical parameters of the accepted variation of consumable cups.

• Assess the shelf life of the accepted variation of consumable cup.

METHODOLOGY

Preparation of Value-Added Dough

Three variations of the value-added dough were made by processing and combining the flour blends of whole wheat, rice bran, dehulled chickpea flour, groundnut cakeand enriched with of pomace of apple, beetroot and molasses extract as per the composition depicted in table 1. The flour mix proposed for the value-added dough fulfilled all the functional properties[9].

Formulation of Different Variations of Consumable Cups

Development of Consumable Cups Using Value-Added Dough

Hundred grams of value added dough from all the three formulations were rolled out separately. Thereafter, steel was used as a stencil and the consumable cups were carved out with a knife. Cups from each variation were carved out with 100g of value-added dough consumable cups. The cup shaped dough were cast on top of steel cup and were bakedat 166^{o}C for 15 minutes[4].It was observed that they got detached from the steel cup. After bringing down to room temperature they were stored in air-tight containers until needed.

Acceptance of the Consumable Cups by Organoleptic Evaluation

All the three variations of the consumable cups were evaluated to check the acceptability of each variation of consumable cup for its appearance, color, aroma, flavor, texture and overall acceptability by untrained judges using a 9-point Hedonic Rating Scale.The 9-point Hedonic Rating Scale was used wherein the highest score was coded as 'like extremely', and the lowest score was coded as 'dislike extremely'.

Evaluation of Performance Attributes

The performance attribute of consumable cups with wet and dry ingredients on the basis of its functionality was assessed by untrained judges using 5-point Descriptive Rating Scale. The 5-point Descriptive Rating Scale was used wherein the highest score was coded as 'extremely competent, and the lowest score was coded as 'extremely incompetent'.

Evaluation of Nutritional Properties of the Accepted Cups

The organoleptically accepted variant was assessed for nutrient composition using standard laboratory procedure[10]. The nutrients assessed include energy, carbohydrates, protein, fat, and fiber.

Phytochemical Analysis of the Accepted Cups

The phytochemicals assessed for in the organoleptically approved variation include, phytic

acid, tannins, oxalates, saponins, trypsin inhibitors, and polyphenols[10,11,12,13].

Determination of Shelf Life of the Consumable Cup

The shelf life of the product was assessed for the accepted variation by storing in an air tight package under room temperature.

RESULTS AND DISCUSSION

Analysis of Organoleptic Attributes of the Developed Consumable Cups

Nine-point hedonic rating scale method was adopted to estimate the acceptance of the developed products in terms of appearance, colour, texture, taste, flavor and overall acceptability. Totally thirty untrained respondents were used for sensory analysis.

As evident from the above table the Organoleptic scores of developed consumable cups on different characteristics such as appearance, colour, taste, texture, flavor, and overall acceptability reveal that variation was exemplary in all aspects. Duncan's multiple-range statistical analysis proves that there was significant difference in the overall acceptability of all the variations of developed consumable cups. Increased proportion of wheat flour in Variation 3 has made variation 3 to be more acceptable compared to Variation 1 and Variation 2. Research studies disclose that consumers embrace edible cutlery and crockery as a nutritious and healthier alternate to plastic cups and spoons since they could be eaten even as a snack, thus proving the acceptability of edible cutlery[14].

Performance Attributes of Consumable Cups

From the above tabular representation, it can be perceived that all the three variations of the consumable cups have shown significant differences between each other or "between groups" as illustrated by the duncan testing method. The variations, namely, variation 1(V1), variation 2(V2), and variation 3(V3) contrasted in their ability to deliver their function as a cup in both wet and dry foods, as evident from their significance value which was less than 0.05.Thus, out of the three variations of Consumable cutleries with all the seven ingredients incorporated in them, variation 3 was found to be most consented by the untrained respondents during sensory and functionality evaluation. More the wheat flour firmer the structure and hence the functionality was

Table 1. Optimized Quantity of Ingredients for Formulation of Consumable Cups

Ingredients	Level of incorporation		
	Variation 1 (V1)	Variation 2 (V2)	Variation 3 (V3)
Wheat flour (g)	40	50	60
Rice bran (g)	20	15	10
Dehulled chickpea flour(g)	20	15	10
Groundnut cake(g)	5	5	5
Apple pomace(g)	5	5	5
Beet root pomace(g)	5	5	5
Molasses(ml)	5	5	5
Total	100	100	100

Table 2. Duncans Multiple Range Test forOrganoleptic Analysis of the Developed Consumable Cups

Variations	Appearance	Colour	Texture	Taste	Flavour	Overall Acceptability
Variation 1	8.20 ± 0.48^{a}	8.00 ± 0.64^{a}	7.96 ± 0.61^{a}	8.20 ± 0.61^{a}	8.20 ± 0.61^{a}	7.93 ± 0.52^{a}
Variation 2	8.33 ± 0.47^{a}	7.93 ± 0.73^{a}	7.76 ± 0.50^{a}	8.30 ± 0.46^{a}	8.30 ± 0.46^{a}	8.03 ± 0.61^{a}
Variation 3	8.93 ± 0.25^{b}	8.36 ± 0.49^{b}	8.86 ± 0.34^{b}	8.96 ± 0.18^{b}	8.96 ± 0.18^{b}	8.46 ± 0.50^{b}
Significance	0.00*	0.00*	0.00*	0.001*	0.00*	0.00*

*= 5 % significance. Mean± standard deviations with different superscripts within a column are significantly different at ($p \leq 0.05$)

better in variation 3. Similar results were found in a study by Natarajan et al., which stated that when soaked in hot liquids for a long time the spoons went soggy[15]. The accepted variation was further assessed for its nutritional and phytochemical profile.

Nutritional Profile of the Accepted Variation of Consumable Cups

Nutritional assessment showed that the 100 gms of consumable cups provide 354 Kcals (majorly from wheat flour and small proportion from chickpea flour, groundnut cake and molasses), 74.2 g of carbohydrates (majorly from wheat flour and small proportion from chickpea, groundnut cake and molasses), 10.8 gms of protein (Wheat flour, Chickpea flour and groundnut cake), 1.5gms of fat (Wheat flour, Chickpea flour and groundnut cake) and 4.6 gms of dietary fibre (Rice bran and Pomace), which was sufficient to full fill 57% carbohydrate, 20% protein, 6% fat, and 12% dietary fibre requirement for men per day and 57% carbohydrates, 24% protein, 6% fat, and 12% dietary fibre requirement per day of women. Literature states that the edible cutleries prove to be a source of carbohydrates, protein, fibre, minerals like iron and calcium, B complex vitamins and low in fat[16].

Table 3. Statistical Analysis of the PerformanceAttributes of the Developed Cups

Variations	Performance with Liquid Foods	Performance with Solid Foods
Variation 1	2.03±0.21[a]	3.7000±0.79[a]
Variation 2	1.56±0.16[a]	3.8667±1.01[a]
Variation 3	2.66±0.17[b]	4.2667±0.74[b]

*= 5 % significance. Mean± standard deviations with different superscripts within a column are significantly different at ($p \leq 0.05$)

Table 4. Nutrient Composition of Consumable Cups

S. No	Proximate composition/100g	Accepted Variation (V3)
1.	Total calories(kcal)	354
2.	Carbohydrates (g)	74.2
3.	Protein (g)	10.8
4.	Fat (g)	1.5
5.	Dietary fibre (g)	4.6

Phytochemical Properties of the Accepted Variation of the Consumable Cups

The presence of phytochemicals in the accepted variation of the consumable cup were assessed and catalogued in table 5. The presence of these phytochemicals can be owed to the use of ingredients like wheat flour, dehulled

Table 5. Phytochemical Properties of the Accepted Variation of the Consumable Cups

S. No	Phytochemicals	Composition (mg/kg)
1.	Phytic acid	1.6
2.	Tannin	8.5
3.	Oxalate	0.8
4.	Saponin	2.2
5.	Trypsin inhibitor	0.5
6.	Total polyphenols	++

Fig. 1. Different Variations of Consumable Cups

Table 6. Cost Comparison with Commercially Available Consumable Cups

S.no	Product	Ingredients	Cost
1.	Kumbhaa Brown 90 ml Consumable Biscuit Tea Cup - India	Corn starch, tapioca starch, wheat flour, soya flour, baking powder and added flavour.	4.50/piece
2.	Edible Cups – Tamil Nadu (Madurai)	Maida, rice, starch, soya lecithin, cocoa powder or vanilla powder	13.93/piece
3.	Consumable cups (Product developed in this study)	Wheat flour, rice bran, dehulled chickpea flour, groundnut cake, beet root pomace, apple pomace, molasses	3.89/piece

chickpea flour, pomaces, and groundnut cake. The incorporation of the suitable ingredients in the formulation of consumable cups have improved their nutritional and phytochemical attributes and hence regular consumption of this reduce oxidative stress, inflammation, obesity, cardiovascular diseases, diabetes mellitus, and cancer[4,5,6].

Shelf Life of the Consumable Cup

The shelf life of the product was assessed for the accepted variation 3(V3). The consumable cup was stored in the air tight packaging to check the shelf life. It had a shelf life of approximately 120 days. The addition of preservatives may help the cups to be fresh for even two years[17]. 1 % of sorbic acid, as anti-fungal agent had been used to increase the shelf life of edible spoons[18,19].

Cost Calculation

When calculated, the cost of the making of 100 g of dough was found to be ¹ 7.78**.**Since 100g of value-added dough carved out 2 cups, the cost of each cup was ¹ 3.89. The cost calculation for preparing 1 consumable cup comprises of all ingredients, namely, whole wheat flour, rice bran powder, dehulled chickpea flour, groundnut cake powder, beetroot pomace, apple pomace and molasses, and charges for fuel and appliance usage. Compared with industry standards, the manufacturing cost has proved to be quite competitive and is tabulated in Table 6.

CONCLUSION

Thus this study aimed to formulate nutritive edible cups utilizing wheat flour as the major ingredient, and the by-products of the food industry namely rice bran, dehulled chickpea flour, groundnut cake, pomace of beetroot, apple, and molasses in different proportions, thereby providing a solution to disposal of waste products from food industry also have been proven to have multifaceted benefits owing to the type of ingredients used and their nutritional value. Ingredients incorporated from all the food ingredients will ensure that the person using these cups meet their food as well as nutritional requirement on a daily basis. Apart from this, the cups have been demonstrated to house a variety of phytochemical components, especially those lacking in the diet of people in current times.From the usability perspective, the consumable cups is apt in catering to its functionality withboth hot and cold, wet and dry food products. It has shown to not take over the flavour of the food consumed with the help of it as well as exhibit a agreeable flavor of its own when consumed individually as a snack.

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Conflict of Interest

The authors declare no conflicts of interest.

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