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Bio-Friendly Edible Cutlery- An Effective Alternative to Plastic Disposable Cutlery

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Abstract

Most of the Pakistani citizens have been using non-biodegradable utensils which take hundreds of year to decay into environment, polluting both the landfills and the water. To avoid use of such non-biodegradable material, edible cutlery has been developed in the current study with all-natural ingredients i.e. the blend of rice, sorghum and millets. Different flour blends were analyzed for functional properties. Water holding capacity (WHC) for Blend A, Blend B and Blend C were found to be 47.70 ± 1.120, 45.97 ± 0.950 and 44.33 ± 0.587, respectively. Oil Binding Capacity (OBC) values for three blends ranged from 135.16 ± 2.31, 102.76 ± 1.078 and 101.03 ± 0.896 for blend A, blend B and blend C respectively. Blend A shows the highest values of solvent retention capacity (SRC) for all three set of solutions i.e. 45.8±0.28 for sucrose, 46.0±0.0 for lactic acid and 44.6±0.5 for sodium carbonate than the other two blends. The Blend A was selected for the formation of product as more retro-gradation during baking led to a product of high tensile strength which is a demanded feature in the edible cutlery as well as the sensory analysts recommended the sample A on the basis of overall acceptability. The edible cutlery is found to contain 2.68%, 1.75%, 1.82%, 4.7% and 0.8% per cent moisture, ash, crude fat, crude protein and crude fiber respectively. The proximate analytical values obtained are found to be in acceptable limits, making the newly developed edible cutlery acceptable. Sheets used for preparing edible cutlery were cut into pieces and the samples of sheets were buried into the sterile soil were degraded completely in sterile soil within 5 to 7 days. The cutlery made in this study is found to be delicious, healthy as well an environmental friendly, and will be able to cut down the use of plastic and thus reducing the heaps of chemically toxic compounds released into the environment during its degradation.

Keywords: Edible cutlery, Post meals snack, Sorghum, Environmental friendly, Bio-degradable

Introduction

In this fast era of modern world, most of the population has been involved in jobs. Therefore, it is very difficult for them to cook or wash the utensils for their daily uses. This has increased the use of disposable plastic containers which has now proven to be harmful for human due to its toxic and non-degrade able nature. Plastic contains bisphenol, a toxin which is considered as endocrine disruptors and carcinogens. Plastic often leaches out into the food from the plastic bags in which it is kept however it is dangerous for the health and its allowed value in a food should not be more than 60 ppm. This problem can be resolved by producing and using bio-friendly edible cutlery instead of plastic (Godswill and Godspel 2019).

Millets are reported to be sustainable in adverse climatic situation and it considered to be a source of macro and micro nutrients (Ushakumari, Latha *et al.* 2004). Sorghum (*Jawar*) has been utilized by a large population of the world as a source of dietary proteins and calories provider (Dykes and Rooney 2006). This gluten-free cereal is the powerhouse of nutrition which adds a great flavor to gluten free baking. It carries a number of nutritional and therapeutic benefits in diet. It also gives a delicious alternative to other types of grains and cereals usually eaten all over the world (Poshadri, Kumar *et al.* 2019). Dry sorghum contains 163 calories per ¼ cup serving.46% of sorghum protein is absorbed,

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whereas in wheat 81% is absorbed and 73% in corn, ¼ cup serving consist of carbohydrates 36 grams and fiber 4 gram (Leder 2004).
Sorghum is rich in a variety of nutrients, including B vitamins, which play an essential role in metabolism, neural development, and skin and hair health (Soetan, Olaiya *et al.* 2010). Moreover, the fiber in sorghum reduces blood cholesterol levels and thus decreasing the risk of heart diseases. 16% of daily value of fiber can be obtained by one serving of sorghum (Devi, Vijayabharathi *et al.* 2014). It's also a rich source of magnesium, a mineral that's important for bone formation, heart health, and over 600 biochemical reactions in human body, such as energy production and protein metabolism (Xiong, Zhang *et al.* 2019). In addition, sorghum is high in antioxidants like flavonoids, phenolic acids, and tannins. Eating a diet rich in these antioxidants can lower oxidative stress and inflammation in human body (Dykes and Rooney 2006).
Rice is one of the leading food crops of the world and is a staple food of over approximately one-half of the world population (Singh, Kaur *et al.* 2005). Rice production in China has a spectacular increase in the recent years and is approximately 30 per cent of the total rice production of the world (Zhang 2007). Rice that is low in amylose and high in amylopectin is sticky in the wake of cooking. It is ideal for risottos and rice puddings, sticky rice (glutinous rice) is likewise favored in Asian cooking since it is anything but difficult to eat with chopsticks. High edibility is one of the drawbacks of the carbs in sticky rice. For a high-carb sustenance, great absorbability isn't generally positive since it might cause an unfortunate spike in glucose, particularly among diabetics (Li, Prakash *et al.* 2016).
Keeping in mind the nutritional importance of millets, sorghum and rice; and the need of biodegradable utensils, it was attempted in the current study to develop edible utensils with blend of rice, sorghum and millets. The prepared cutlery was evaluated for chemical as well nutritional constituents.

Materials and Method

Chemicals and Glassware

Analytical grade chemicals were used for analysis. All glassware was pre-rinsed with 10% HCl followed by deionized water.

Raw Materials

Wheat flour (Sunridge Foods), rice flour (NY Collection), sorghum flour (Daraz.pk), sugar (locally available), butter (Nurpur, Fouji Foods Ltd.), salt (Shan Foods Pvt. Ltd.) and vanilla essence (Bush Boak Allen Pakistan Pvt. Ltd.) were purchased from a super market at Karachi.

Processing of Edible Cutlery

The dough was prepared with a blend of rice flour, sorghum flour and wheat flour to establish three different compositions as Sample A, Sample B and Sample C. The compositions are recorded in Table-1. Each sample of blend of flours was added with constant amount of other ingredients such as sugar, salt, vanilla essence and butter separately. Then the mixture of three distinct samples were manipulated with the lukewarm refined water. The dough was kneaded in a kneader for 8 - 10 minutes. The dough was further kneaded by hand for 30 - 60 seconds to form smooth shape. Pre sheeting of the dough was carried out by hand then with the help of dough sheeter of desired length and breadth. The sheets of dough were then cut into desired size and shape. The dough was molded into spoons, forks and bowls and then baked in an aluminum tray at 180ºC for 40-60mins. The utensils were cooled before carried for further analysis.

Table 1: Composition of Newly Developed Edible Cutlery

S.No	Ingredients (g)	Sample A	Sample B	Sample C
1.	Rice flour	40gm	30gm	30gm
2.	Sorgham flour	30gm	40gm	30gm
3.	Wheat flour	30gm	30gm	40gm
4.	Sugar	15gm	15gm	15gm
5.	Butter	1.5gm	1.5gm	1.5gm
6.	Salt	0.35gm	0.35gm	0.35gm
7.	Vanilla Essence	Traces	Traces	Traces

The cutlery prepared in this study is shown in Figurre-1.

2 SENSORY ANALYSIS:

Figure 1: Newly Developed Edible Cutlery

Organoleptic Evaluation

Standard 9-point hedonic scale procedure was used to carry out the sensory (organoleptic) evaluation. Cutlery samples were served to 35 trained/and semi trained panelist to analyze the organoleptic score of each parameter (Amerine, Pangborn *et al.* 1965).

Proximate Analysis

Physical tests of the final product such as moisture, ash, and chemical analysis such as fat, protein, and starch were carried out according to the standard methods of AOAC [15], whereas the crude fiber, dietary fiber content, Solvent Retention Capacity (SRC), Water Holding Capacity (WHC), Oil Binding Capacity (OBC) and Sodium Dodecyl Sulphate (SDS) sedimentation tests were performed according to standard methods by AACC [16]. The calorific value was estimated by Bomb Caloriemeter (Chemists and Horwitz 1975).

Biodegradability Test

Soil Burial Test

Sheets used for preparing edible cutlery were cut into pieces and the samples of sheets were buried into the sterile soil for specified amount of time and gradual biodegradation of samples was checked on daily basis (Leja and Lewandowicz 2010).

Statistical analysis

Statistical analysis was carried out by ANOVA. All the results were the average of three replicates (Gomez and Gomez 1984).

Results and Discussion

Different flour blends were analyzed for functional properties and the results are depicted in Table 2. The sedimentation tests were utilized to decide the nature of the flour which is most reasonable for the readiness of palatable cutlery. Blend A showed the highest percentage of water holding capacity with the value of 47.70 ± 1.120. A decreasing trend was found for Blend B with a value of 45.97 ± 0.950 and Blend C with 44.33 ± 0.587. The blend A contains maximum amount of rice flour along-with sorghum and wheat flours. Amylose and amylopectin of rice and the gluten of wheat flour in blend A have the ability to develop starch-water bond and retain high amount of moisture. Therefore, the combined effect of these flour might be a reason of the highest water holding capacity of blend A.

Sodium Dodecyl Sulphate (SDS) sedimentation values are found to be in a range of 11.43 ± 0.115 ml, 21.833 ± 0.763ml and 23.9 ± 0.854 ml for blend A, blend B, blend C respectively. The high SDS sediments values might be due to good quality gluten protein present in blend C, while the other blends might have lower gluten-protein content.

Table 2: Functional Properties of Composite Flour Blends

S. No	Parameters	Blend A	Blend B	Blend C
1.	**WHC**	47.0±0.04	45.9±0.95	44.06±0.95
2.	**OBC**	135.16±2.31	102.76±1.078	101.03±0.896
3.	**SDS Sedimentation**	11.4±0.11	21.8±0.76	23.9±0.85
4.	**SRC (Sucrose)**	45.8±0.28	42.5±0.5	42.6±0.6
5.	**SRC (Lactic Acid)**	46.0±0.0	42.8±0.7	41.0±0.9
6.	**SRC (Sodium Carbonate)**	44.6±0.5	41.6±0.9	41.0±0.08

Blend A shows the highest values of SRC for all three set of solutions i.e. 45.8±0.28 for sucrose, 46.0±0.0 for lactic acid and 44.6±0.5 for sodium carbonate than the other two blends. The results for SRC of different solvents showed minute variation which may be due to the composition of blends, as the ratio of three flours used in blends are more or less equally related to each other. The major function of SRC looks at the glutenin, gliadin and pentosan attributes of the flour, and the level of starch harm in the flour. These qualities portray the flour's capacity to retain water amid the blending procedure and its capacity to discharge that water amid the preparing procedure (Guttieri, Bowen *et al.* 2001). Oil Binding Capacity values for three blends ranged from 135.16 ± 2.31, 102.76 ± 1.078 and 101.03 ± 0.896 for blend A, blend B and blend C respectively. The results conclude that blend A shows higher values for water holding capicity and has oil binding capacity. The Blend A was selected for the formation of product as more retro gradation during baking led to a product of high tensile strength which is a demanded feature in the edible cutlery. SRC measures general ingestion and also improved retention identified with particular macromolecular segments of flour. The major function of SRC looks at the glutenin, gliadin and pentosan attributes of the flour, and the level of starch harm in the flour. These qualities portray the flour's capacity to retain water amid the blending procedure and its capacity to discharge that water amid the preparing procedure (Guttieri, Bowen *et al.* 2001).

The sensory score of freshly prepared pasta has been summarized in Table 3. The sensory analysts recommended the sample A on the basis of overall acceptability, which was found to be above average. The sample A contains the highest amount i.e 40%w/w of wheat flour. The texture, colour, flavor and mouth feel for sample A was found to be 8.5, 8.3, 8.9 and 8.5 respectively. The overall acceptability of Sample A was found to be very high 8.56 as compared to other sample i.e 6.9 for Sample B and 6.71 for Sample C. Sample A was found to be highly acceptable and more consistent than the other two samples.

Table 3: Standardization of Newly Developed Edible Cutlery

S.No	Parameters	Sample A	Sample B	Sample C
1.	Texture	8.5±0.01	7.1±0.02	6.44±0.02
2.	Colour	8.3±0.01	7.0±0.02	7.0±0.02
3.	Flavour	8.9±0.02	6.6±0.03	7.0±0.03
4.	Mouth Feel	8.5±0.03	6.9±0.04	6.4±0.02
5.	Overall acceptability	8.56±0.02	6.9±0.66	6.71±0.07
6.	Remarks	**Selected**	Not Selected	Not Selected

Proximate Analysis of Newly Developed Edible Cutlery has been summarized in Table-4. It is evident from Table 4 that the edible cutlery is found to contained 2.68%, 1.75%, 1.82%, 4.7% and 0.8% per cent moisture, ash, crude fat, crude protein and crude fibre respectively. The Acid Detergent Fiber (ADF) and Neural Detergent Fiber (NDF) were calculated as 1.7% and 3.7%. Percentage of starch was 4.82. The energy value was obtained as 334.4 kcal/100 gram of the sample. Food quality can be maintained by maintaining less moisture content in the food commodities; that will reduce the deterioration of food by decreasing microbial growth. For quality of dried products, moisture content <10% is believed to be more appropriate (El Wakeel 2007). The ash content and fat contents in the sample A were found to be in acceptable limits, making the newly developed edible cutlery acceptable. The values for fat, fiber and proteins found in the present studies are comparatively less making the product acceptable.

Table 4: Proximate Analysis of Newly Developed Edible Cutlery

Parameters	Sample A
Moisture (%)	2.68%
Ash (%)	1.75±0.02
Fat (%)	1.82±0.01
Protein (%)	4.7±0.04
Fiber (%)	0.8±0.03
Dietary Fiber	
ADF (%)	1.7±0.05
NDF (%)	3.7±0.05
Starch (%)	4.82±0.10
Energy (Kcal/100g)	334.4±0.05

Biodegradability Test

The results were found to be satisfactory, as expected; various samples of sheets used for preparing edible cutlery were degraded completely in sterile soil within 5 to 7 days. Each sample was gradually broken down into smaller pieces and started decaying in 3 to 4days and the complete decay was observed in 5 to 7 days. The biodegradability test is time consuming method, but the cutlery prepared in the current study has taken only 5 to 7 days for complete biodegradation (Leja and Lewandowicz 2010). The process of degradation of the sheet prepared in the current study is may be due to the bacteria in the soil and organic substances present. The microbial organisms transform the substance through metabolic or enzymatic processes. It is based on two processes: growth and co-metabolism. In growth, complete degradation of substance buried in the soil is carried out to convert it into carbon and energy. Co-metabolism is defined as the metabolism of an organic compound in the presence of a growth substrate that is used as the primary carbon and energy source (Fritsche and Hofrichter 2001).

Conclusion

Edible cutlery has been developed in the current study with all-natural ingredients i.e. the blend of rice, sorghum and millets. Different flour blends were analyzed for functional properties, and WHC were found to be 47.70 ± 1.120, 45.97 ± 0.950 and 44.33 ± 0.587for Blend A, Blend B and Blend C respectively. Oil Binding Capacity values for three blends ranged from 135.16 ± 2.31, 102.76 ± 1.078 and 101.03 ± 0.896 for blend A, blend B and blend C respectively. Blend A shows the highest values of SRC for all three set of solutions i.e. 45.8±0.28 for sucrose, 46.0±0.0 for lactic acid and 44.6±0.5 for sodium carbonate than the other two blends. The Blend A was selected for the formation of product as more retro gradation during baking led to a product of high tensile strength which is a demanded feature in the edible cutlery. The sensory analysts recommended the sample A on the basis of overall acceptability, which was found to be above average. The edible cutlery is found to contained 2.68%, 1.75%, 1.82%, 4.7% and 0.8% per cent moisture, ash, crude fat, crude protein and crude fibre respectively. The proximate analytical values obtained are found to be in acceptable limits, making the newly developed edible cutlery acceptable. Sheets used for preparing edible cutlery were cut into pieces and the samples of sheets were buried into the sterile soil were degraded completely in sterile soil within 5 to 7 days. The cutlery made in this study is found to be delicious, healthy as well an environmental friendly, and will be able to cut down the use of plastic and thus reducing the heaps of chemically toxic compounds released into the environment during its degradation.

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