"Edible Cutlery by Utilizing Agriculture Waste for Sustainable Environment."

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Abstract: Highly increasing urbanisation and industrialization has produced the enormous amount of solid waste. Overall country today is facing environmental pollution due to undisputable solid waste particularly, plastic waste disposal has increased rapidly in the last few decades. Scientist are working on safely disposing plastic solid waste and recovering wealth out these waste material. For this many scientist and entrepreneurs have developed an innovative idea of cutlery which is edible as well as bio-degradable. Aim of this paper is too aware about cutlery is the best option to replace plastic waste. review the bits and pieces of work being done on cutlery in various part of the world. It includes with cutlery developed by researcher and entrepreneur also been reviewed. The future scope of research in this domain has also been looked. Finally, we believed that edible cutlery could be a potential source for replacement of plastic cutlery, proving scope for environmental protection, leading to sustainable development.

Keywords: Edible cutlery, waste management, Sustainable, spoon, cup, plate, bowl

INTRODUCTION:

Today's world facing the issue of solid waste disposal particularly, plastic solid waste due to rapid population explosion, urbanization large extent of migration towards urban area (A. A. Abdulrasoul et. al., (2016). Development of industries has supplemented to the sorrow of solid waste management. The concept of Solid waste management and the technology behind solid waste landfilling has been well understood in developed countries (khatib et. al., 2007). The developed countries have chalked out a regulated program for solid waste disposal, while developing countries are still continuing to use unsophisticated method like open landfill dumping (Berkun et. al., 2005). It has been reported that in some nation, majority of the municipal budget has been used for collection and transportation of the wate, except very little used for processing, resource recovery and disposal of the waste (Enacts KMC changing lives Creating impact Delhi)

World economic forum cites indicate that the global plastic production has risen from 15 million tons in 1964 to 311 million tonnes in 2014 and the number is expected to triple by 2050.

The average time taken for a plastic bottle to decompose is 450 years. Waste production is particularly problematic in large cities whose economic development precedes waste management infrastructure (Edible cutlery of DFRL on display at aero India show-star of Mysore) To combat this even increasing problem, many researchers around the world have come with an alternative solution known as edible cutlery. Edible cutlery is picking up momentum in various countries. Concern over environmental pollution and degradation of people's health due to consumption of plastic, many scientist and entrepreneur have developed innovative cutlery which is edible and also bio-degradable. Edible cutlery is the solution for sustainable development and environmental protection in the future. Literature shows that no review has been conducted on this topic. With an aim of providing an overall view of the edible cutlery being currently used, this paper discusses the different types of edible cutlery being manufactured and marked by various organisation. We have also reviewed some of the individual efforts in this topic from an edible artistic perspective. Edible cutlery is not a new concept. It has been introduced way back in the 1400s. Bred bowl was first introduced in 1427 to impress the British Duke. The Duke was so impressive by the innovation that he gave the inventor an Irish nobleman money to open a bread-bowl shop in city now known as Dublin. Same as the tosada bowl was introduced in the 1930s, made of stale tortilla. The modern bowl a version of a Mesoamerican design, has since been modified in every possible way, down to the mini betty Crocker version. Later in the 1980s, the sourdough bowl was introduced in the aim of marketing San Francisco's clam chowder. The Bay area popularized it and the restaurants in USA have used it as a way to charge more for the soup.

Edible cutlery from various country and researcher, entrepreneur and their product:

INDIA

Bakey's was founded in 2011 by a groundwater researcher, Narayana peesapathy to produce edible cutlery as a replacement for the plastic cutlery. Around 120 billion plastic cutlery is being disposed every year in India. In a bid to cure this precarious situation in India and around the globe peesapathy founded this company which produces edible cutlery (spoon, fork, and even chopsticks) made out of dried millets (jowar or sorghum), rice and wheat. He was working in the international crop research institute for semi-arid topics Hyderabad, where he conducted research on ground water. He concluded that growing dryland crops like jowar helps to stabilize the level of groundwater, and this was the reason why he chose to use jowar for the edible cutlery production. Bakey's production has attracted wide attention with orders coming from USA and UK. Their edible cutlery is fully vegan, preservative free, trans fat free, and dairy free. The energy cost is minimized waste and maximizes efficiency. In addition, the lower usage for each spoon (less than 2% of the weight per spoon), allows the spoon to have very long shelf life of 2years while maintaining their crispiness. Bakey's is now selling 1.5 million spoons in India every year. The flavour used by them include ginger-cinnamon, ginger-garlic, cumin, celery, black-pepper, mint-ginger, and carrot-beetroot. Delhi based project called "patradaya" makes edible bowls in three sizes the project helps the afghan refugees in India. The defence food laboratory (DFRL) has been producing and promoting the technology related to edible cutlery.

TAIWAN

The sugu company of Taiwan has produced edible plates and others edible cutlery items, and in 1986 claimed to have invented the world first range of edible tableware as means to replace disposable tableware

JAPAN

Japanese designer Nobuhiko arikawa of rice design company has created edible cutlery for Orto café in japan. The plates, bowl and chopsticks are intended to replace disposable paper cutlery The pieces are made from hardtack, a biscuit dough made from flour, water and table salt, shortening and yeast, no eggs or dairy product are used. The bowl can be found at the edible cutlery shop sold at a price of 130 yen each and are sold in sets of ten. The optimum thickness and texture of the edible bowl with a good flavour was determined by trial and error method. Since, bowl started marketed in 2010 the response has been good at home and abroad. Around 50 countries outside japan have ordered them for parties and event. At present, only the bowl is being marketed as the plates and spoon are deficient in withstanding normal eating utensil usage The bowl produced by rice design is found to last up to 45 days from the date of purchase In addition to Rice-Design, a small family-owned business named Marushige Seika K.K., operated by Sakakibara Katsuhiko, is also engaged in the development of edible tableware. Katsuhiko originates from Hekin, a fishing town located approximately 300 kilometers west of Tokyo. The company produces plates using shrimp, salt, and potato starch. These products are in demand not only among food vendors at baseball stadiums and local festivals but are also attracting international orders. The plates and bowls are available in various oval and rectangular designs and are more durable than they appear, capable of holding water for up to 30 minutes.

Initially, the company manufactured monaka crust made from wheat, but due to its poor performance when exposed to moisture, they transitioned to using shrimp crackers. Their e-tray product line also features plates flavored with sweet potato or onion. The company aims to supply edible plates for the 2020 Tokyo Olympic Games and has plans to expand into producing edible knives and forks, with the goal of reducing waste in their hometown. Meanwhile, a Yokohama-based food packaging company called Honest is producing small cups made from edible seaweed. Measuring approximately 2 cm deep and 4 cm in diameter at the base, these cups are particularly popular with mothers of young children as they serve various purposes in lunchbox packaging. Although originally intended for sale exclusively in restaurants, strong consumer demand led to the launch of an online store in 2007. Since then, the company has expanded its range with new flavours and resalable packaging, which helps prevent the seaweed from becoming soft due to humidity. Masaki Miyata, president of Honest, emphasized that the company uses only Japanese seaweed. They are now receiving an increasing number of international orders, including from the United States**.** Meanwhile**,** research into the production of edible tableware using 3D printing technology is gaining significant traction these days. Keio University in Tokyo is actively working on a project to manufacture eating utensils such as chopsticks, spoons, and cups using rice flour**,** and has developed a prototype 3D printer specifically for this purpose**.** They also plan to create edible toys for children in day-care centres and nursing homes**.**

BELGIUM

A couple of Belgian designers have come up with a new range of edible food containers that are eco-friendly and tasty. The young entrepreneurs – Helene Hoyois and Thibaut Gilquin, are making containers using potato starch, water and oil. These containers are tough enough to retain all sorts of food and sauces, and also digestible. They can be disposed of if not eaten as they are biodegradable. They received financial support from a corporation called Wallonia Creative to set a company called "Do Eat", 30 km away from Brussels with over 30 employees. They plan to make glasses, cutleries and bowls in the future.

POLAND

Biotrem's manufacturing process for wheat bran-based tableware was initiated by Mr. Jerzy Wysocki. Their state-of-the-art and rapidly expanding facility produces a diverse range of completely biodegradable dishes and utensils made from natural, edible wheat bran. From one ton of clean, edible bran, they are able to produce approximately 10,000 pieces of plates or bowls. The tableware is suitable for serving both hot and cold foods, and can be safely used in both traditional and microwave ovens.

The available sizes include plates with diameters of 28 cm, 24 cm, and 20 cm, bowls with a 20 cm diameter, and an oval bowl measuring 24 x 16 cm. The company also accommodates custom orders for specific dimensions and shapes, up to a maximum diameter of 28 cm. Biotrem has established distribution centers in Denmark, Italy, Norway, the UK, France, the Netherlands, Austria, Hungary, Sweden, and the United State.

SOUTH AFRICA

Munch Bowls Private Limited was founded by Georgina de Kock and has been based in the Western Cape, South Africa, since 2011. The company manufactures crunchy, edible wheat-based bowls branded as Munch Bowls. These bowls are an eco-conscious, consumable substitute for plastic and polystyrene containers. The edible wheat bowls are capable of holding foods like stir-fries, salads, and similar dishes for over 60 minutes. They can also contain stews and thick soups for 30 minutes or longer, all while retaining their crunch and structural integrity. The product has a shelf life of 15 months, and its crisp texture can be revived by placing it in an oven at 70–100°C for 3 to 5 minutes. The bowls are made from flour, bran, sugar, and oil, and are completely vegan, containing no artificial colorants and no yeast.

USA

Loliware was co-founded by Chelsea Briganti and Leigh Ann Tucker, who combined their environmental awareness and innovative spirit to create a new category of sustainable drinkware. The product was officially introduced in March 2015. Loliware is the first and only edible, single-use cup (Figure 5) that is completely free of plastic, gluten, and gelatine, as well as being non-GMO, entirely natural, safe, and non-toxic. These cups are both biodegradable and edible. They are produced using seaweed (agar), along with organic sweeteners, and natural flavours and colours extracted from fruits and vegetables. The currently available flavour is a blend of grapefruit and yuzu. These cups are suitable for serving food at room temperature, chilled, or frozen. Loliware products are now used in over 40 countries spanning 6 continents. After use, they can be discarded on the ground or dissolved within minutes when exposed to hot water. The only notable drawback is the price—a set of four cups costs $11.95.

As of now, they are not sold outside the United States. Choc Amos is a company that manufactures edible cookie-based cups**.** It was established by Michelle Silberman**,** a young businesswoman and innovator**.** The company creates a unique form of edible tableware using premium-quality ingredients**,** along with cookie moulds and cutters**.** Their products are made available for purchase through an online marketplace**.**

FRANCE

At the French bakery Poilâne, the cutlery consists of crispy crackers and cookies, which are used to enjoy the shop's appetizers and sweet treats. A curry-flavored fork pairs perfectly with mango chutney or hummus, while a shortbread cookie spoon serves as a decorative topping for ice cream or functions as an espresso stirrer.

Individual Entrepreneur or artistic

This section focuses on edible tableware designed by individuals driven by artistic or experimental interests rather than commercial goals. These edible items were created using their creative and exploratory skills. Dutch artist Geke Wouters has developed a remarkable series of ultra-thin edible bowls crafted from vegetables such as carrots, peppers, beetroot, leeks, tomatoes, and others. Each bowl is made through a unique drying and shaping technique that transforms the natural materials into delicate, paper-thin layers, resulting in a complex cellular texture. No two bowls are identical. Since the collection was produced purely from an artistic standpoint, its functionality for holding liquids is not guaranteed.

A collection of delicate and visually appealing edible cups and saucers was created by Padiglione-Italia. These items are crafted from sacramental bread, traditionally used in Catholic churches. Michelle Ivankovic produces plates made from pasta. Her ingredients include flour, water, eggs, plant-based colouring, and gelatine. To ensure the usability of the plates, a water-resistant gelatine coating is applied to the surface.

Diane Leclair Bisson's edible bowls are part of the Edible Project and are crafted from various fruits and vegetables. These bowls are suitable for serving both hot and cold dishes. In a recent initiative, students from the Piet Zwart Institute in Rotterdam have repurposed kitchen appliances into devices for creating biodegradable and edible tableware. These transformed tools, known as Rollware, consist of rolling pins designed with carved patterns in the wood, allowing users to imprint designs onto dough to form edible tableware. The collection also includes Extrudough, a line of eco-friendly tableware produced using a modified meat grinder.

Literature Review

Environmental pollution has become a growing concern worldwide, particularly due to the massive rise in the disposal of plastic plates and utensils over recent decades. In response, several individuals and organizations are actively working to offer sustainable alternatives to this persistent issue. Some companies, such as Bakey's, Rice-Design, and Poilâne, are focused on producing only edible spoons and forks, whereas others like Biotrem offer plates, and companies like Loliware specialize in edible cups. Munch Bowls, in contrast, concentrates on selling edible bowls.

A review of the available literature clearly indicates that no single company or organization currently produces all categories of edible utensils. Table I presents a comparison of the various

products offered by different innovators. Although a few sustainable alternatives have been proposed, it remains uncertain whether consumers are willing to adopt edible tableware. People in some regions, particularly developed nations, are more open and enthusiastic about adopting this eco-friendly shift. However, the situation is quite different in other parts of the world. This is highlighted by the fact that several Asian-based companies are receiving international orders from other continents. In developing countries, people tend to be less inclined to purchase edible utensils, as they are accustomed to using plastic, and a behavioural shift may require more time and effort.

Another critical factor under discussion is the cost of producing edible tableware. According to Narayana Peesapathy, the founder of Bakey's, although people are showing interest in his products, the price of a single edible spoon still exceeds that of a plastic one. He aims to reduce costs by promoting millet cultivation, which is one of the primary ingredients. Similarly, Loliware's edible cups are considered too expensive by many consumers. As a result, unless the pricing of edible tableware becomes more affordable, widespread adoption may remain limited. Otherwise, we risk continuing to face the same environmental challenges associated with plastic waste pollution.

On a positive note, the edible tableware industry presents a new opportunity for farmers, who can choose to grow crops used in manufacturing these products, potentially increasing their income. Additionally, it's not only farmers who stand to benefit—the utensil manufacturing sector also has the potential to expand its reach. For example, students from the Piet Zwart Institute in Rotterdam have developed custom rolling pins that can be used to create edible tableware.

Moreover, contemporary artists are becoming increasingly interested in designing objects using biodegradable materials such as fruits and vegetables. Literature suggests that even these artists are motivated by the goal of protecting the environment from the negative impacts of solid waste build-up. Although they may not intend to commercialize their edible creations, their work serves to raise awareness among the public that edible cups and saucers can be a viable substitute for plastic utensils.

Conclusion

Plastic waste disposal remains a significant environmental concern. Among various types of plastic waste, the disposal of plastic utensils plays a major role and has a substantial impact on the environment. In response, some innovative entrepreneurs have introduced edible tableware as a sustainable alternative to traditional plastic utensils. This paper presents a comprehensive review of edible tableware designed and commercialized by various innovators across the globe. Even the small-scale contributions of individual artists in the development of edible utensils have been examined. There exists vast potential for advanced research in this emerging field. Many developers report that their edible tableware can retain liquids only for 15 to 20 minutes, after which the material begins to disintegrate. However, young children, who typically consume meals over extended periods, may require utensils that can hold liquids for longer durations. Hence, further studies are needed to identify materials with minimal absorption capacity, as there is a chance that the tableware may soak up soups or beverages poured into them.

Additionally, the shelf life of edible tableware is another critical area that warrants investigation. The rate at which these utensils decompose is also a key factor. Faster degradation would undoubtedly be advantageous for the environment, contributing to greater ecological sustainability. Since the tableware is edible, discarded items could serve as a food source for microorganisms and insects present in the soil. Therefore, it is essential to conduct studies on the safety of such consumption by various living organisms.

Another major challenge lies in developing cost-efficient moulds capable of producing multiple types of edible utensils within a single facility. Moreover, the labour required for operating and maintaining such manufacturing units poses an additional difficulty. In this regard, research aimed at automating these systems could play a crucial role in improving efficiency.

Despite facing numerous obstacles, including those related to cost, raw materials, workforce, biodegradability, and durability, edible tableware holds great promise as a viable solution for environmental conservation and sustainable progress.

Table-1: Comparison of product sold by different entrepreneur

Description	**Bakey's**	**Rice Design**	**Do Eat**	**Biotrem**	**Biotrem**	**Munchbowls**	**Loliware**
Origin	India	Japan	Belgium	Poland	South Africa	USA	USA
Entrepreneur	**Narayana peesapathy**	**Nobuhiko arikawa**	**Helene hoyois and Thibaut gilquin**	**Jerzy wysocki**	**Georgina de kock**	**Chelsea briganti and leighann tucker**	**Michelle silberman**
Type of cutlery produced	Spoon ,fork and chopsticks	Plate bowl and chopsticks	containers	Bowl and plates	bowl	cups	Cookies cups
Cost	A pack of 100 spoons cost 300 rupees (approx. 4.62 US cents)	A bowl costs 130 yen(approx. 1.6$)	A pack of 25 costs 9.95 pounds (approx. 13.78$)	A pack of 25 costs 9.95 pounds (approx. 13.78$)		A pack of 4 costs 11.95$	A box of 6 would range from 25 to 30$
Centers elsewhere				Denmark,Italy, Norway, UK, France, Netherlands, Austria, Hungary, Sweden and USA			
Order from abroad	**Yes**	**Yes**	**Yes**	Centers are located in different countries	**Yes**	**Yes**	**Yes**
Shelf life	2 years if sealed	-	6 months	-	15 months	12 months if sealed	-

Carbon footprint	-	-	-	1.3 to 1.6 g of CO2/kg	-	-	-
Placing in oven	-	-	**Safe**	**Safe**	-	-	-
Longevity of holding liquid	Spoons get soggy after 10 minutes	-	2 hours or less	Hot liquid thick soups up to 30 minutes and hot thin liquids up to 20 minutes	60 minutes	-	-
Type of food that can be served	Hot and cold liquids	-	Hot or cold preparations but not water and alcohol	Hot and cold liquids	Hot and room temperature liquid	Only room temperature and cold liquid	-

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