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A Sustainable Approach to the Comprehensive Analysis of the Nutrient Content and Phytochemical Profile of Industrial Food Waste

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ABSTRACT

This research paper offers a comprehensive analysis of the nutrient content and phytochemical profile of industrial food waste, focusing on key elements including nitrogen, phosphorus, potassium, carbon, and hydrogen, as well as bioactive compounds. The study involves the characterization of various types of food waste streams to elucidate their nutritional composition and bioactive compound content. Analytical techniques such as NPK analysis, carbon and hydrogen analysis, and phytochemical qualitative analysis are employed to quantify and identify the presence of essential nutrients and bioactive compounds in the waste excrement materials. Additionally, present paper explores the potential value-added opportunities through product development using extracted bioactive compounds. Perspectives from recent research that advance knowledge of industrial food waste as a valuable resource for nutrient recovery and bioactive compound extraction, thereby fostering sustainable food waste management practices and promoting the development of value-added products for various industries.

Keywords Industrial food waste, Nutrient content, Phytochemical qualitative analysis, Value added products.

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INTRODUCTION

Food waste is a critical problem that is increasingly affecting societies globally due to the continuous increase in world population. A recent study examining food demand through meta-analysis suggests that the global population, projected to increase by 10% by 2050, is driving a corresponding rise in food demand. Failure to adequately meet this demand poses a significant risk of global hunger. The primary objective of the 12.3 Sustainable Development Goal of the United Nations is to lower the amount of food waste per person and related management expenses while eliminating unconsumed food waste and packaging materials by the year 2030. Consequently, addressing the treatment and eco-friendly reuse/recycling of industrial food waste emerges as a critical priority for the food industry. Nutrient analysis and phytochemical qualitative analysis of industrial food waste play a crucial role in understanding its composition and potential for resource recovery. By conducting such analyzes, valuable information can be obtained regarding the nutrient profile and potential applications of food waste in various sectors such as agriculture, energy production, and waste management (Lin *et al.* 2018) and environmental conservation. Additionally, the characterization of food waste can help in identifying strategies for reducing disposal treatment. The enhancement of waste management practices and the generation of food refuse. This comprehensive research paper aims to address the following objectives: 1. Evaluate the nutrient profile of different types of food waste from various industries (Puglia *et al.* 2021). 2. Identify potential applications and processed goods products that can be obtained from leftover food. 3. Assess the environmental impact of the management of food scraps and potential benefits of adopting sustainable management practices (Pham *et al.* 2015). 4. Explore the technologies and processes that can be used for energy recovery from food waste, for example anaerobic digestion, composting with bioconversion. The objective of this investigation is to furnish a study of the existing literature on food waste management and the nutrient profile of food waste. By analyzing existing research papers and studies conducted, this report aims to enhance the comprehension of the potential worth of food waste and offer valuable insights into efficient waste management solutions that can minimize environmental impact and maximize resource recovery. Recently, there has been a growing acknowledgment of the substantial issue of food waste and the need for effective management strategies (Hodaifa *et al.* 2019). Research efforts have focused on understanding the nutrient profile of food waste to identify potential applications and items with additional value that can be produced from it. Furthermore, the environmental effects of wasted food disposal have spurred interest in sustainable management practices such as anaerobic digestion, composting along with bioconversion to reduce waste and extract valuable resources (Sheets *et al.* 2015). By reviewing the current strategies implemented by governments and organizations, this paper aims to shed light on the progress made in food waste management and highlight areas that require further attention and improvement. Overall, this research paper will provide a comprehensive overview of food waste management, including the nutrient profile of food waste and its potential applications, environmental impact assessment, energy recovery technologies, and current strategies and policies. The goal of this study paper is to give an in-depth look at how to handle food waste and what nutrients are in food waste (Bhat (ed.) (2021). Anaerobic digestion for food and agricultural wastes has the potential to enhance the economic feasibility and environmental sustainability through the incorporation of responsible land application practices and emerging technologies. Additionally, this study aims to analyze and review the current strategies and policies implemented by governments and organizations to manage food waste and promote circular economy principles. Through this research paper, we aim to contribute to the growing body of knowledge on food waste management and its nutrient profile. The research paper's findings will offer significant decisions for policymakers, waste management practitioners, and researchers involved in the subject of food waste management.

Fig. 1. Dried sample of sweet corn and tomato waste.

Fig. 2. Dried tomato peels and seeds sample stored in air tight bags.

MATERIALS AND METHODS

Study area

Major food waste study based on the different vegetables and fruit processing/food processing industries in Anand city, State: Gujarat, India

Sample collection and pretreatment

Tomato and sweet corn food waste were collected from the food processing industry from Anand city. It was dried at 60ºC in hot air dryer before use. Slurry type collected waste start to deteriorate if not properly air dried as shown in (Fig. 1) and stored in air tight bags as per (Fig. 2). After air drying the bags are stored in deep freeze at -4ºC to preserve food waste in its original state (Pandya *et al.* 2017). Traditional solvent extraction methods use solvents like methanol, chloroform, methyl chloride, benzene which are widely used and cost effective than other methods. For qualitative analysis methanol was used as solvent and for oil extraction by Soxhlet method hexane was used as solvent. Food waste is perishable in nature as it is extremely moisturized waste. Solid-liquid extraction is widely used to recover dietary fibers and carotenoids without disturbing original properties.

Methods for qualitative analysis

Alkaloids, flavonoids, phenolics, tannins, saponins, and steroids are among the significant phytochemicals

Table 1. Method of phytochemical analysis**.**

Sl. No.	Detection of	Test	Method
1	Alkaloids	Picric acid test	Few ml of filtrate + 3-4 drops of 2% picric acid solution
2	Carbohydrates	Molish's test	2 ml filtrate + 2 drops of alcoholic alpha naphthol + 1ml conc. H_2SO_4
3	Reducing Sugars	Benedict's test	0.5 ml filtrate + 0.5 ml venedict's reagent + boil for 2 minutes
4	Amino Acids	Ninhydrin test	2 ml filtrate + 2 drops of ninhydrin solution
5	Protiens	Xanthoproteic test	Plant extract + few drops of conc. Nitric acid
6	Flavenoids	conc. H_2SO_4 test	Plant extract + conc. H_2SO_4
7	Phenolic compounds	Potassium dichromate test	Plant extract + few drops of potassium dichromate solutin
8	Tannins	Braymer's test	1ml filtrate + 3 ml distilled water + 3 drops of 10% ferric chloride solution
9	Saponins	Foam test	20 ml water + 50 g extract + shake vigorously for 20 minutes
10	Phytosterols	Salkowski's test	Filtrate + few drops of conc. H_2SO_4
11	Fixed oil and fat	Spot/ Stain test	Little quantity of plant extract is pressed in between to filter paper
12	Lignin	Labat test	Extract + gallic acid

that are distributed throughout the plants. Qualitative screening was performed as per following (Table 1) (Shaikh and Patil 2020).

Methods for CHN analysis

Elements carbon, hydrogen and nitrogen are analyzed by Element Analyzer instrument (Model: Elemertar Analysensysteme GmbH, Germany, Make: Unicube, SICART). In this analyzer, carbon, hydrogen and nitrogen analysis is based on high temperature combustion or pyrolysis of the sample and conversion of the elements into gaseous products (Firdaus *et al.* 2018). Separation of gases by direct temperature programmed desorption column and detection by TCD detector.

Methods for P and K content

The test is performed by using WD-XRF. Wavelength Dispersive X-ray Fluorescence (WD-XRF) is a precise analytical technique used to ascertain the elemental composition of various materials. Wavelength Dispersive X-ray Fluorescence (WD-XRF) is a precise analytical technique used to identify the elemental composition of various materials. (WD-XRF-Model: AxiosMAX, Make: PAnalytical, Netherland, SICART- VVNagar, Anand). The analyzable materials include solids, liquids, powders, and filters. WD-XRF is a rapid, precise, non-destructive technique that often necessitates minimal sample preparation (Horf *et al.* 2021).

Nutrition profile of dried food samples were studied as per standard FSSAI manual.

RESULTS AND DISCUSSION

The results of the food wastage ratio analysis reveal notable disparities between tomato waste and sweet corn waste generated from industrial processing as per (Table 2). The study found that the food wastage ratio for sweet corn waste was significantly higher compared to tomato waste, indicating a higher proportion of discarded material such as corn cob, husk relative to the total raw material. Phytochemical qualitative analysis of food waste is important for unlocking the nutritional and functional potential of these materials, leading to the development of sustainable solutions for both human health and environmental conservation.

The results indicated varying levels of nutritional content across different waste streams, reflecting the diverse origins and processing methods of the food materials. Specifically, the testing identified significant quantities of proteins and carbohydrates in the samples, suggesting potential for energy and nutrient recovery from these waste streams as per (Table 3). Additionally, trace amounts of essential vitamins and minerals were detected, emphasizing the inherent worth of food waste as a rich source of micronutrients. These findings underscore the importance of explor-

Table 2. Results of qualitative screening .

Sl. No.	Phytochemical qualitative screening Detection of	Observation	Result
1	Alkaloids	An orange color	-
2	Carbohydrates	A violet ring	+
3	Reducing sugars	Green/yelloW/red colour	+
4	Amino acids	Purple colored ring	+
5	Protiens	Yellow colored solution	+
6	Flavonoids	Orange color	+
7	Phenolic compounds	Dark color	
8	Tannins	Blue-green color	-
9	Saponins	Formation of 2cm thick foam layer	-
10	Phytosterols	Red color	-
11	Fixed oil and fat	Oil stain on filter paper	+
12	Lignin	Olive green color	

Table 3. Nutrition profile of dried food waste.

Sl. No.	Nutrition profile analysis Quality characteristics per 100 g	Dried food waste
1	Energy (kcal)	489.9
2	Total fat (g)	28.1
3	Saturated fat (g)	12.21
4	Cholesterol (g)	0
5	Carbohydrate (g)	46.3
6	Sugar (g)	2.7
7	Sodium (mg)	163.4
8	Protein (g)	15.2
9	Trans fat (g)	0
10	Added sugar (g)	0

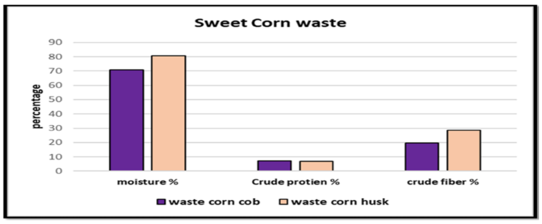

Fig. 3. Moisture content, crude protein and crude fiber analysis from sweet corn waste.

ing strategies for valorizing food waste to harness its nutritional potential and mitigate resource wastage in industrial operations (Patel *et al.* 2021).

The analysis of dried sweet corn waste samples revealed important insights into their nutritional composition. The results indicated a higher crude protein content in corn cob is 7.19%, crude fiber content is higher in corn husk which is 28.67%, and moisture content is higher in corn husk which is 80.6% as shown in Fig. 3. These findings suggest that sweet corn cob and husk waste contains a significant proportion of protein and fiber, making it a potentially valuable resource for various applications, including animal feed or biofuel production. The high moisture content observed in the samples indicates the level of water present in the dried waste material, which is crucial for determining its stability and storage requirements. Overall, these results underscore the potential of dried sweet corn waste as a valuable source of nutrients and highlight opportunities for its utilization in sustainable resource management practices.

The carbon and hydrogen analysis of the tomato and sweet corn waste samples revealed important insights into their elemental composition as per (Fig. 4). The results indicated a carbon content of tomato waste is 49.52% and a hydrogen content is also higher in tomato waste which is 7.49%, which is essential for understanding their potential applications and environmental impact. By showing following results we can summaries that tomato waste is rich in carbon and hydrogen elements than sweet corn waste. The carbon content serves as an indicator of the organic content of the waste, while the hydrogen content provides insights into its chemical structure

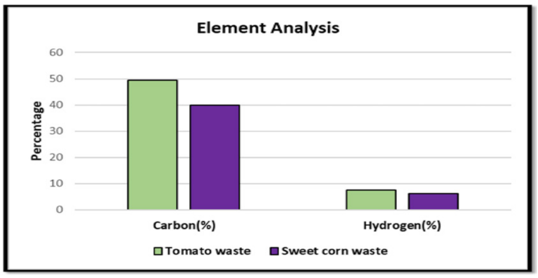

Fig. 4. Carbon and hydrogen % in tomato and sweet corn waste.

and energy potential. Overall, these results contribute to our understanding of the nutritional and chemical properties of the food waste samples, guiding future research and development efforts aimed at valorizing these materials for various purposes, including bioenergy production, composting, biofertilizer and soil amendment (Sindhu *et al.* 2020).

The NPK analysis of tomato waste, sweet corn waste, and mixed vegetable waste provided valuable insights into their nutrient composition. The results revealed significant variations in the concentrations of nitrogen (N), phosphorus (P), and potassium (K) in various vegetable species processing waste streams. Specifically, the analysis showed that tomato waste had an NPK content of 2.95%, 3.96%, and 36.75%, respectively, sweet corn waste had an NPK content of 1.53%, 5.53%, and mixed vegetable waste had an NPK content of 2.46%, 4.94%, and 5.85%, respectively as shown in Fig 5. These findings highlight the diverse nutrient profiles of the waste materials, reflecting differences in their origins, processing methods, and compositions. Tomato waste represents higher NPK values than other ones. Understanding the NPK content of the waste streams is essential

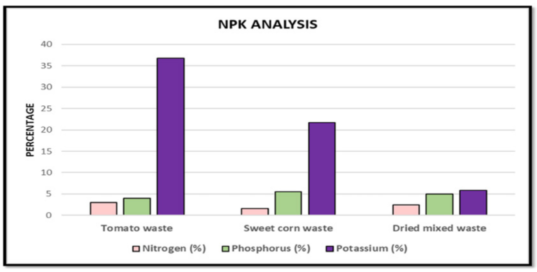

Fig. 5. NPK analysis from tomato, sweet corn and dried mixed waste.

for identifying opportunities for nutrient recovery and utilization in agricultural applications, such as composting or soil amendment, anaerobic digestion thereby promoting sustainable resource management practices.

CONCLUSION

Phytochemical qualitative analysis plays a critical function in comprehending the composition of food waste and identifying potentially valuable bioactive compounds present in these materials. Phytochemical qualitative analysis is crucial in understanding the composition of food waste and identifying potential bioactive compounds. Food waste often contains antioxidants, antimicrobials, and phytonutrients, which can have significant health benefits. These compounds can be used as additives in food and beverage products to enhance nutritional profiles and extend shelf life. This aligns with environmental sustainability principles, as it reduces the environmental impact of waste disposal. The analysis of potassium (K), nitrogen (N), phosphorus (P), hydrogen (H), and carbon (C) content, along with the food nutrition profile, provides valuable insights into the composition and potential value of food waste. Carbon and hydrogen represent organic substances found in food scrap, while phosphorus and potassium are important macronutrients contributing to plant growth and metabolism. The nutrition profile reveals the presence of various nutrients, including proteins, carbohydrates, fats, vitamins, and minerals, which may vary depending on the type and origin of the food waste. Food waste often contains valuable nutrients and bioactive compounds that can be harnessed for various purposes, including animal feed, fertilizer production, and bioenergy generation. Understanding the composition of food waste allows for the development of innovative strategies for its valorization, contributing to environmental sustainability and resource efficiency. By utilizing food waste as a bioavailable source of nutrients and energy, we can mitigate the environmental impact of trash disposal while fostering business opportunities and the circular economy. Exploring the nutrition profile of food waste opens avenues for novel applications in food, agriculture, and bio-based industries, ultimately aiming to develop an environmentally sustainable food system.

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