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Utilization of Food Wastes to Prepare Film Forming Biomolecules

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Abstract: Food wastes are produced by a variety of sources, ranging from agricultural operations to household consumption. About 38% occurs during food processing. Disposal of such quantities of waste represents a challenge as it is the main cause of environmental problem. Apart from being used as animal feeds or fertilizers, the research conducted in the last decades clearly showed that the by-products resulted from processing of plant materials contained valuable nutrients which could be exploited in the development and production of new biomolecules. There is an increasing and constant interest in finding new sources of plant-derived polysaccharides—the bio agro-waste streams being very promising in this sense. The main aim of this investigation is to extract cellulose from food wastes (Potato peels and Rice bran) and the extracted biomolecule is converted into HPMC. It is a semi-synthetic polymer which possesses good film forming characteristics. Thus this work not only utilizes food waste efficiently but also helps in developing a valuable raw material for food and Pharmaceutical industries.

Keywords: Cellulose, HPMC, Film, Food wastes, Potato peels, Rice Bran

I. INTRODUCTION

Tremendous amounts of municipal solid waste are being generated and dumped of at landfills every day. The largest single category is represented by biodegradable food waste, which being landfilled results in several environmental and economic issues. Food waste, constituting the largest MSW category (38%), is being sent to the landfills as much as 3,648 tons per day (tpd). The wastes generated from the food industry can be separated into two main categories: plant-derived wastes and animal-derived wastes. The animal-derived wastes can be divided in three subcategories: (i) meat products, (ii) fish and seafood and (iii) dairy products, whereas the plant-derived wastes can be classified into four subcategories: (i) cereals (e.g. rice bran, wheat bran and brewers' spent grain), (ii) root and tubers (e.g. potato peel, sugar beet and molasses), (iii) oil crops and pulses (e.g. sunflower seeds, soybean seed and olive pomace) and (iv) fruit and vegetables (e.g. orange peel, grape pomace, apple pomace, tomato skin and pomace) [1].

Disposal of such quantities of waste represents a challenge and an environmental problem. Apart from being used as animal feeds or fertilizers, the research conducted in the last decades clearly showed that the by-products resulted from processing of plant materials contained valuable nutrients which could be exploited in the development and production of new biomolecules. Regarding the potentially marketable components present in foods wastes and co-products, the aim is to exploit high value components such as proteins, polysaccharides, fibers, flavor compounds, and phytochemicals as nutritionally and pharmacologically-functional ingredients. Nearly 90% of vegetables' and fruits' dry matter is composed of carbohydrates, of which 75% is sugars and hemicellulose, 9% is cellulose and 5% is lignin; whilst, the major plant biopolymers with largest application possibilities are cellulose and starch.

Thus, the main focus of the feasibility study would be on cellulose and starch. Cellulose, the most abundant natural biopolymer on earth, is considered as one of the most promising polymeric resource. It has many advantages, such as low cost, biocompatibility and biodegradability, which not only allow it to be used in furniture, clothing, packaging, paper and medical products in our daily life, but also give the potential in numerous applications as bio-based materials, such as fibers, films, food casings and membranes [2-6]. Therefore, effective utilization of cellulose will reduce the consumption of our limited fossil resources so as to protect the environment. In recent years, considerable attention has

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been directed towards biodegradable cellulose-based materials, due to the serious "white pollution" made from the non-biodegradable plastic film.

Chemically modified polymers have been extensively investigated in order to develop new biomaterials with innovating physic–chemical properties [7-9]. Important classes of modified polymers are cellulose ethers, such as methylcellulose (MC), hydroxypropylmethylcellulose (HPMC), hydroxyethylcellulose (HEC) and carboxymethylcellulose (CMC). Cellulose is the most abundant polysaccharide found in nature; it is a regular and linear polymer composed of (1→4) linked β-D-glucopyranosyl units. This particular β-(1→4) configuration together with intramolecular hydrogen bonds gives a rigid structure. (5) Hydroxypropylmethyl cellulose (HPMC) is one of the most general hydrophilic polymers, which is extensively used in many fields owing to its ease of use, excellent film-forming ability, good biocompatibility and biodegradability.

Starch and HPMC are good candidates for making not only hard but also soft gelatin capsules. One of the limitations of using them is the initial high capital investment. Potato peels and rice bran are common food wastes and agricultural waste all around the world. These two sources will contribute to efficient utilization of such wastes with the additional benefit of preparing the raw materials in an inexpensive way. Cellulose is one of the most widespread biopolymers, complex carbohydrate and organic compound on Earth and it can be converted into HPMC in few steps. Main utilization of HPMC is the production of capsule shells, replacing the animal derived gelatin in conventional two piece capsules. The main aim of this study is to recover cellulose from food wastes and to check its suitability for vegetable capsules by preparing films.

II. EXTRACTION OF CELLULOSE

Rice husk was grinded, the ground rice husk washed with distilled water and dried at 100°C. Further, 100 g of rice husk was treated with 100 ml 10% NaOH aqueous solution and 900 ml distilled water with stirring on a magnetic stirrer for half an hour at constant temperature (60°C). The obtained slurry is filtered and liquid part consist of cellulose, washed with distilled water and then neutralized by adding 1N HCl drop by drop. The obtained solution was spin casted at 500 rpm and was allowed to dry in a vacuum oven at 60°C.

Extraction of Cellulose from Potato Peels

The potatoes were hand peeled and the removed mass was washed with water to rinse away soil and other bulk contaminants from the peels. The cleaned peels were added into water at a water-to-pulp ratio of 20:1 and agitated as slurry using a blender for 10 mins to remove the majority of potato flesh. The resulting slurry was screened using a 250 mm sieve and repeatedly washed with distilled water. Potato peel waste is comprised of starch, cellulose, hemicellulose, lignin and other impurities, and therefore required several pretreatment steps including alkali treatments and chlorite bleaching to isolate its cellulosic component prior to acid hydrolysis. Initially, the peel waste was treated with a 0.5 N aqueous sodium hydroxide solution at 80°C for 2.5 h under mechanical agitation .The treatment was done three times in order to completely eliminate the lignin, hemicelluloses, and other impurities.

After each treatment, the pulp was filtered and washed with distilled water using a 75 mm sieve to remove the alkali solution and dissolved impurities. The alkali washing was followed by bleaching with 2.3% sodium chlorite solution in an acetate buffer (pH=4.9). The purpose of the bleaching was to remove any organic residues. The bleaching treatment was carried out twice at 70°C for 2 h each time. The extracted cellulose fibers from the potato were washed, dried and weighed.

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III. CONVERSION OF CELLULOSE TO HPMC

Methyl chloride that is used as an alkylation reaction here is first obtained by the addition of methanol to cellulose followed by heating. The cellulose (74 g) is converted into methyl cellulose (73 g) on heating. The 73 g of Methyl Cellulose obtained is reacted with propylene oxide to form 49 g Hydroxy propyl methyl cellulose. The following tests were done to confirm the formation of HPMC (Fig. 1).

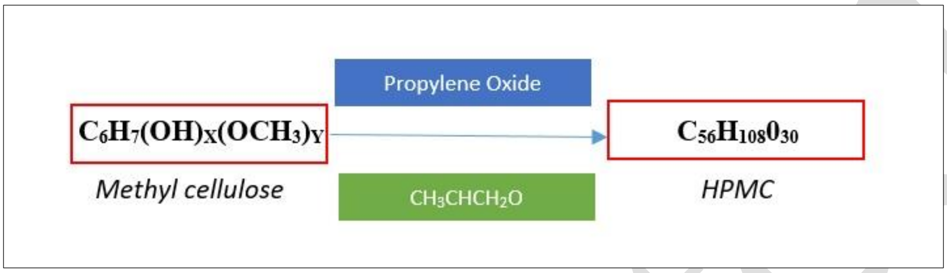

Fig. 1. Formation of HPMC.

IV. DETECTION TESTS

The following detection tests were done:

Benedicts Test
To 1 ml of filtrate solution is treated with Benedict’s reagent and heated gently. Reddish precipitate indicates the presence of reducing sugars.

Biuret Test
Few mg of the extract residue is taken in water and 1 mL of 40% sodium hydroxide solution is added.

Spot Test
After adding a drop of 1% solution of copper sulphate, violet or pink color indicates the presence of protein in the sample. The sample is pressed or rubbed on a clean white sheet of paper, a greasy spot (translucent spot appears) indicates the presence of fat in the sample. Negative results indicate the absence of proteins, fats and carbohydrates and presence of HPMC.

Schultz Test
A Few drops of Schultz Reagent is added to the solution of the powder obtained. The appearance of Purple color solution indicates the presence of Cellulose.

Test for Methyl Cellulose:
5 ml of the sample is mixed with 25 ml of 95% alcohol solution. To this 2 to 3 drops of Saturated NaCl was added. The absence of precipitate indicates the presence of Methyl Cellulose [10,11].

V. CHARACTERIZATION STUDIES FOR HPMC

pH Test
Thus 1% solution of synthesized HPMC was prepared and checked.

Aggregate Test

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The sample was gently added to the top of 100 ml of water ina beaker and was allowed to disperse over the surface and tapping the top of the container to ensure an even dispersion of the substance. It was then allowed to stand for 1-2 min to check for aggregate formation. The presence of powdered aggregate on the surface indicates that the sample is HPMC

Viscosity Test
The sample was added to 100 ml of boiling water and stirred using magnetic stirrer to form slurry. It is then cooled to 10° and checked for its appearance (clear or turbid).

Ninhydrin Test
To the sample solution, 9 ml solution of sulphuric acid and water in the ratio of 9 in 10 is added and shaken well. It is further heated in a water bath for exactly 3 minutes and immediately cooled in an ice bath and 0.6 ml of ninhydrin TS was added to it. Shake and allow to stand at 25°.

Film Test
2-3 ml of the sample from test two was taken and poured into a glassslide as a thin film and the water was allowed to evaporate. The formation of clear and coherent film indicates that the sample is HPMC

Flocculation Test
The sample solution prepared in test 2 is added to exactly 50 ml of water in a beaker. Insert a thermometer into the solution and stir it on the hot plate and begin heating at a rate of 2-5 °/min. Determine the temperature at which the turbidity increase begins to occur and designate this temperature as the flocculation temperature. The flocculation temperature should be higher than 50°.

Preparation of HPMC Film
Film formation is the most important characteristic of HPMC to be used as capsule shell in oral medications.2% (2 g in 100 ml), 6% (6 g in 100 ml) and 10% (10 g in 100 ml) HPMC solution were prepared in a beaker. Water is brought to a boil and HPMC powder is added slowly with constant stirring. Then, the solution is allowed to cool. The solutions were poured into glass petridishes and dried at room temperature.

VI. EXPERIMENTAL RESULTS

Percentage Yield
The cellulose was successfully extracted from both rice bran and potato peels and the amount obtained was calculated as stated in the tabulations. The appearance of cellulose was found to be slightly crystalline and watery. The amount of cellulose yield from rice bran (54%) is found to be more when compared to amount obtained from the potato peels (27.7%). The yield of cellulose extracted from both the sources is summarized below (Tables 1 and 2):

Table 1. Yield from rice bran.

Rice bran	
Content	**Amount**
Weight of the sample before drying	200 g
Weight of the sample after drying	100 g
Moisture content in the sample (Initial-Final)	100 g
Percentage Moisture content (Initial – Final/Initial)*100	50%
Weight of cellulose obtained from Rice Bran	54 g

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Table 2. Yield from Potato peel.

Potato peels	
Content	**Amount**
Weight of the sample before drying	200 g
Weight of the sample after drying	90 g
Moisture content in the sample (Initial-Final)	110 g
Percentage Moisture content (Initial – Final/Initial)*100	55%
Weight of cellulose obtained from Potato peels	25

Detection Tests

The confirmatory and detection tests were used to detect the presence of other components like carbohydrates, proteins, amino acids and fats and the results were found to be satisfactory. Other tests for hemicelluloses and lignin content were not detected as those constituents are removed during the extraction procedure which is already discussed in research papers. Methyl cellulose conversion was confirmed by Schultz test and sodium hydroxide test (Tables 3 and 4).

Table 3. Confirmation and detection tests were used to detect the presence of other components like carbohydrates, proteins, amino acids and fats.

Tests	Procedure	Observation	Results
Benedicts test	One ml of filtrate solution is treated with Benedict's reagent and heated gently. Reddish precipitate indicates the presence of reducing sugars.	No reddish brown precipitate	Absence of reducing sugar
Biuret test	Water is added to 2 mg of the extract residue and 1 ml of 40% sodium hydroxide solution is added. After adding a drop of 1% solution of copper sulphate, violet or pink color is formed if protein is present.	No violet or pink color	Absence of proteins
Spot test	Sample is pressed or rubbed on a clean white sheet of paper, a greasy spot (translucent spot appears) if the sample contains fat.	No greasy spot	Absence of fat
Schultz test	A few drops of Schultz reagent is added to the sample , the appreance of purple color indicate the presence of cellulose	Appearance of purple color solution	Presence of cellulose
Iodine test	A few drops of Iodine is added to the sample, the appreance of blue black color indicates the presence of starch.	No blue black color	Absence of starch
Sodium hydroxide test	Few drops of saturated Sodium hydroxide solution was added to the sample, absence of precipitate confirms the presence of methyl cellulose.	Absence of precipitate	Presence of methyl cellulose

Tests for HPMC

The identification tests prove that the resultant powder is HPMC by analyzing its various physical and chemical properties.

Table 4. Identification tests for HPMC to analyze its various physical and chemical properties.

Tests	Observation	Results
pH test	The pH was found to be 7.1	Presence of HPMC
Aggregate formation	Formation of powdered aggregate on the surface	Presence of HPMC
Viscosity test	The solution was found to be more viscous than before and the viscosity was found to be 110 cp (2% solution, 20°C)	Indicates that the solution contains HPMC
Ninhydrin test	The solution changes from red to purple	Indicates that the solution is HPMC
Film formation	A thin transparent film is formed	Indicates the film formation ability of HPMC
Flocculation	The flocculation temperature was	Since the temperature is greater
temperature	found to be 80°	than 50° the presence of HPMC is confirmed

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Preparation of Films

The 2% solution of the prepared HPMC powder was too dilute (watery) and a film could not be formed using it. Film prepared using 6% and 10% were good. Thus the HPMC powder synthesized from cellulose which is extracted from the two sources (rice bran and potato peels) exhibited sufficient film forming property (Fig. 2).

Fig. 2 . HPMC powder synthesized from cellulose which is extracted from the two sources.

HPMC film obtained from 10% and 6% solutions that were prepared from the HPMC powder

VII. CONCLUSION

The overall waste production of Potato peels mainly in the fried snack products can be utilized in a useful way by following this procedure. The rice bran which is also used for the extraction of oil has found to have an alternative usage through this project. This alternative method for the production of HPMC will reduce the waste disposal on the whole and make India a better Nation to benefit from the WASTE generated in a food Industry. Thus the efficient utilization of the by-products from food industry can help in reducing the negative cost, reduce environmental pollution, demonstrating sustainability in food industry and that has direct impact on the economy of the country.

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