HYDROLYSIS OF PET FOOD WASTE – PRODUCTION OF REDUCTION SUGARS

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ABSTRACT

The PET food industry has grown over the years, generating significant income. In the production process, different checks mean that part of the product being processed is rejected, generating waste. This study evaluated the use of PET food waste as a substrate for obtaining fermentable sugars. The chemical composition of the residue was 14.02 ± 0.42% protein, 4.81 ± 0.61% lipids, 28.79 ± 3.29% carbohydrates, 12.07 ± 1.66% insoluble lignin, 2.48 ± 0.18% soluble lignin, 11.97 ± 0.01% ash, 27.80 ± 2.00% extractives and 4.5% moisture. Hydrolysis was carried out with 0.5%, 1.0% and 1.5% (v/v) sulfuric acid, and the concentrations of maltose, glucose and fructose were evaluated over the reaction time. The highest levels of glucose (30 g.L^{-1}) were obtained for the reaction with H_2SO_4 1.5% (v/v) after 80 min, with an efficiency of 90%. It was also observed that maltose is generated and degraded in the reaction with the more concentrated acid. The ability to obtain fermentable sugars from this waste, which is generated by a constantly growing industry, is remarkable. In this way, PFW should be considered as a potential substrate in biorefineries, helping to reduce waste generation, as well as in the circular bioeconomy.

Keywords: Industrial waste. Biorefinery. Acid Hydrolysis. Bioprocess.

1 INTRODUCTION

There are more than 167 million domestic animals in Brazil, including dogs, cats, birds, fish and others. The large population of these animals generates a high demand for a specialized industry. Among the different products, pet food had the highest turnover in the sector in 2023, at 78%.[1] Worldwide, this market has an annual turnover of U$150 billion. PET food differs from human food in that PETs need their nutritional requirements to be met with a single feed. In this sense, a wide range of materials are used for production, such as cereal grains (rice, corn, wheat), meats, fat sources (Chicken far and beef tallow) and micro-ingredients (vitamins and minerals).[2] These materials must therefore be processed to obtain the feed, in kible form.

The production stages consist of mixing the material, pre-cooking, extrusion, cooking, sieving, metal removal, sauce blending and refilling, crimping, retort sterilization and cooling. After each stage there is a quality check, ensuring uniformity in the material and the absence of substances harmful to animals. [3] The care taken with the quality of the product and the checks at each stage is due to contamination problems that have been observed in the past. The biggest case was in 2007, when there was a recall of different brands in the USA that were contaminated with melamine, a substance that caused kidney problems in different animals, leading some to die.[4] Checking prevents recalls, but generates a loss of products, which cannot be reprocessed, as they can alter the nutritional balance and contaminate other batches.

Information on losses in this industry is scarce, as is information on what has been done with this material after it has been discarded. Some industries send their waste for composting, generating a fertilizer with a low economic return. As it is derived from food sources, this discarded feed can be used in biorefineries, just as food waste has been used to generate bioproducts [5]. There is an indication of the possibility of co-digestion of expired dog food with corn stover.[6]

In this sense, this study aims to identify the potential of pet food waste to produce fermentable carbohydrates, which can be used for different biotechnological purposes. Acid hydrolysis with sulfuric acid was used to analyze the influence of time on the formation of maltose, glucose and fructose, as described in the next section.

2 MATERIAL & METHODS

The Pet Food Waste (PFW) was obtained from an industry at Recife, Pernambuco, Brazil. The material was dried in an oven at 65 °C for 48 hours, crushed, sieved to a 20 - mesh particle size and stored at – 20 °C for analysis of chemical composition and use. The biomass was characterized for the concentration of extractives, lignin, ashes [7], lipids [8], and protein [9]. Total carbohydrates were determinate by mass difference.

The acid hydrolysis was done with sulfuric acid at three different concentrations (0.5, 1.0 and 1.5% v/v) with 10% of solids. The reaction took place at an autoclave at 121 °C. To evaluate the kinetic, the reaction was performed at the times of 0, 6.7, 13.3, 26.7, 40, 53.3, 66,7 and 80 minutes. The autoclave has a 20-minute heating ramp and a 20-minute cooling time. The reaction time for the study started after complete heating and does not take into account the cooling time. At each time, was analyzed the concentration of maltose, glucose and fructose by High Performance Liquid Chromatography (HPLC).

3 RESULTS & DISCUSSION

The composition obtained from the characterization of PET Food Waste (PFW) was 14.02 ± 0.42% protein, 4.81 ± 0.61% lipids, 28.79 ± 3.29% carbohydrates, 12.07 ± 1.66% insoluble lignin, 2.48 ± 0.18% soluble lignin, 14.61 ± 1.41 total lignin, 11.97 ± 0.01% ash, 27.80 ± 2.00% extractives and 4.5% moisture. There is a considerable difference in the composition of this residue with food waste (FW) from human consumption, which has ample literature for bioprocesses.[5] FW has a protein composition ranging from 3.20 to 42.00%, lipids from 1.00 to 53.00% and carbohydrates from 14.80 to 78.00%.[10] Despite the lower concentration of carbohydrates, hydrolysis into fermentable sugars could be an interesting route for recovering this waste.

Given the raw materials used in the production of pet food, it would be expected that the most common carbohydrate would be starch. The hydrolysis with 0.5% (v/v) H_2SO_4 showed a low concentration of maltose, the dimer produced in the hydrolysis of the polysaccharide (Figure 1 a). There was also a constant concentration of glucose and fructose over time, indicating that hydrolysis was not effective at this concentration. When increasing the concentration of sulfuric acid to 1.0% (v/v) (Figure 1 b) and 1.5% (Figure 1 c) there was an increase in the concentrations of carbohydrates released into the medium, reaching glucose concentrations of over 30 $g.L^{-1}$ after 80 min with 1.5% (v/v) of acid. There was a reduction in the concentration of maltose after 40 min of reaction with 1.5% (v/v) H_2SO_4, indicating a decomposition of this dimer, obtaining more glucose in the medium, which was not observed at the other concentrations. Fructose remained constant in the medium, so it is a carbohydrate that is already present and is not produced during the reaction. The time was an important factor, and the huge concentration was obtained after 80 minutes of hydrolysis.

Starch is made up of two polysaccharides, amylose and amylopectin. Amylose has an amorphous structure and is therefore somewhat recalcitrant, which explains why it is difficult to hydrolyze the substrate in question.[11] The efficiency of the process with 1.5% (v/v) H_2SO_4 was 90%, similar to the results obtained for FW with acid and enzymatic hydrolysis in sequence, after pre-treatment with microwaves.[12] Therefore, despite a lower concentration of carbohydrates, PFW has a relatively easy structure to hydrolyze compared to other biomasses, such as sugar cane bagasse, which requires more steps to obtain simple sugars.[13]

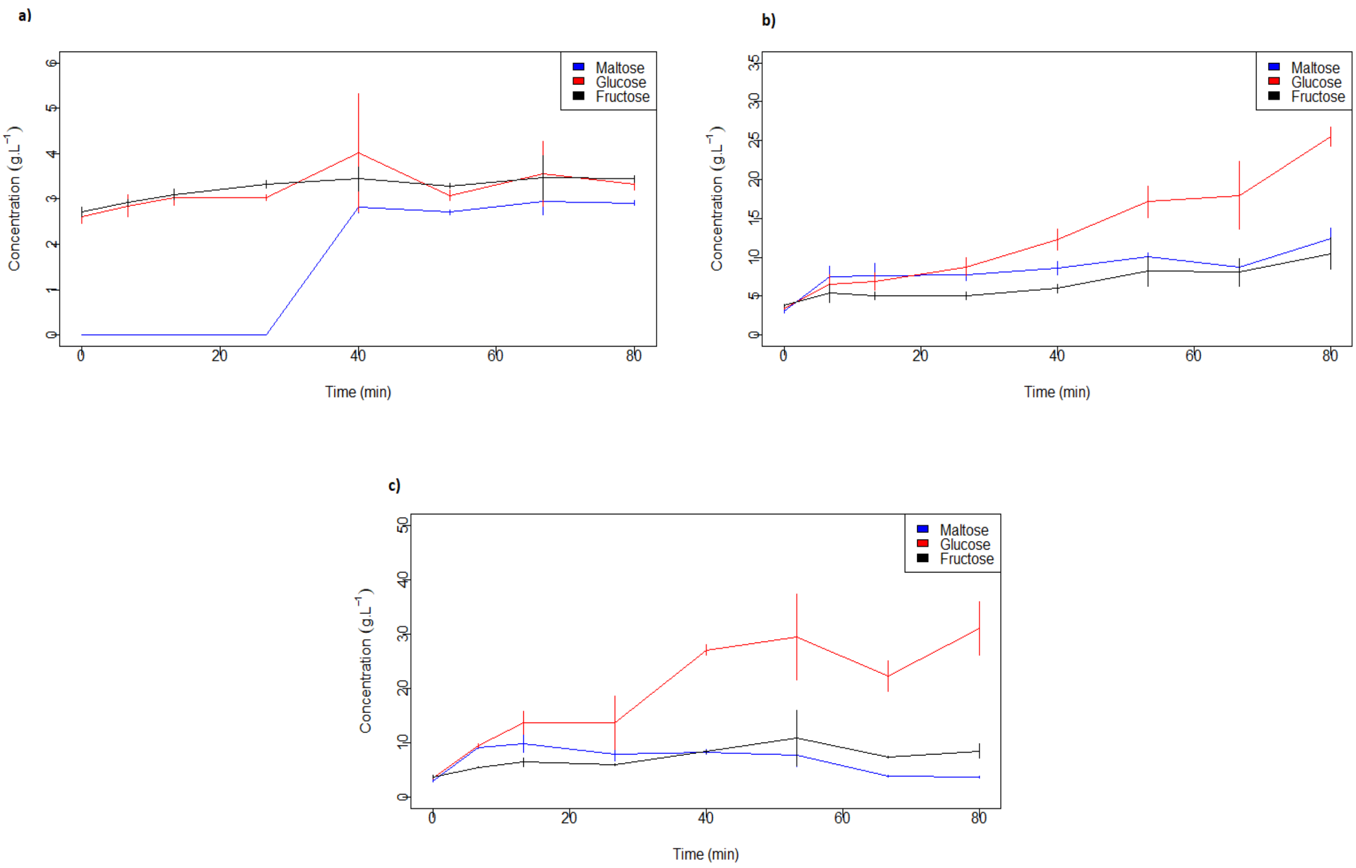

Figure 1 Graph of reaction kinetics as a function of reaction time for the solution of a) 0.5% (v/v) H_2SO_4, b) 1.0% (v/v) H_2SO_4 and c) 1.5% (v/v) H_2SO_4.

4 CONCLUSION

The study reveals the potential of waste from the PET food industry to generate simple carbohydrates, which can be used in biotechnological processes. A hydrolysis efficiency of 90% was observed with H_2SO_4 1.5% (v/v) and a reaction time of 80 minutes. Despite having a lower carbohydrate content than food waste, PFW is easier to hydrolyze. This study did not assess the formation of degradation compounds, such as 5-hydroxymethylfurfural, or the behavior of these hydrolysates in biotechnological processes. However, the ability to obtain fermentable sugars from this waste, which is generated by a constantly growing industry, is remarkable. In this way, PFW should be considered as a potential substrate in biorefineries, helping to reduce waste generation, as well as in the circular bioeconomy.

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