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(RESEARCH ARTICLE)

Physicochemical characterization of two agricultural wastes for the formulation of animal feeds

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Abstract

Waste management is a major problem to which the agricultural and food industries must find solutions. The latter use pineapple in most of the processes for the manufacture of fruit juices. These processes result in tons of waste that are often abandoned on dumps near the processing plants, polluting the water table and the quality of surface water after drainage by rainwater. Our study therefore proposed to find an efficient solution to this problem by valorizing agro-industrial pineapple waste in animal feed. Thus, the physicochemical parameters of pineapple peelings and soybean cakes were determined following protocols of French standards. From the results obtained, it appears that pineapple peelings are rich in fermentable sugars, especially cellulose, a source of energy (34% DM) but poor in total nitrogenous matter (6.86%). As feed is a source of protein, soybean meal was added to pineapple peels for enrichment in total nitrogenous matter. The characterized soybean meal showed that it contains 33.46% of total nitrogenous matter. A more complete characterization of the formulated feeds will have to be carried out for their better use in animal feed.

Keywords: Pineapple peels; Soybean cakes; Physico-chemical parameters; Fermentable sugar

1. Introduction

In Benin, food processing industries face the problem of waste management due to huge amounts of by-products generated. These difficulties are compounded by the underdeveloped or non-existent transformation or conversion of these by-products into products with high added value [1]. All this leads to environmental pollution and a waste of potential food resources. The difficulty in converting by-products stems from the high cost of drying equipment and the lack of simple and suitable alternatives [2].

Benin produces about 400,000 tonnes of pineapple per year, part of which is exported to Europe and the countries of the Hinterland. 28% of total production undergoes artisanal, semi-industrial and industrial processing into fruit juice for marketing or domestic consumption [3].The waste (crown, heart and pineapple peel) from processing varies between 25% to 35% and between 45% to 65% [4, 5]. In addition, soybean meal is piled up and abandoned either in the open air or on dumps, dumped in landfills or rivers near processing industries, causing environmental hazards, both in terms of the atmosphere and the water (surface, underground). They represent high added value products due to their high BOD and COD content [6].

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Previous work has shown that waste from pineapple processing is recycled into pharmaceuticals, composting, biogas, animal feed [7]. Better management of waste from food processing is identified as a major resource for the development of biobased processes [8, 9]. This is why our study aims at the formulation of an animal feed from the combination of waste from pineapple peels and those from soybean meal.

2. Material and methods

2.1. Plant material

The plant material investigated consists mainly of pineapple waste (peelings) and soy cake.

2.2. Methods

2.2.1. Pineapple peels and their treatment

A survey was conducted with small corporations producing pineapple juice to obtain our pineapple peels more easily. Indeed, the semi-industrial and industrial processes for the production of juice make it possible to obtain separately the different parts of waste, namely the peelings, the heart and the crown. This is how the production unit of the ''IRA'' brand located in Allada (Benin) was identified. This unit agreed to provide us with pineapple peelings throughout our study. These were then transported in plastic bins to the Laboratory of Water and Environmental Sciences and Techniques (LSTEE) where they undergo prior treatment. This treatment includes drying in a VWR oven at 105 °C for 24 hours, grinding with a mixer and sieving. The powders obtained (size ≤ 1 mm) are used for the rest of the work which includes the physicochemical characterization and the formulation of the feed. The plate below shows fresh (A) and dried (B) pineapple peels.

A B

Figure 1 Fresh (A) and dried (B) pineapple peels collected from the ''IRA'' fruit juice production unit

2.2.2. Soybean cakes

Soybean meal was used as a source of protein to enrich the feed. They were collected from artisanal processors of soy into cheese for human consumption. Since the residues from these transformations are thrown on heaps of garbage while they still contain nutrients such as proteins, they have been recovered for recycling in animal feed. These cakes were also transported in plastic tubs to the Laboratory of Water and Environmental Sciences and Techniques (LSTEE) for drying at 105 °C in a VWR oven for 24 hours, ground in a blender then sieved to a size of 0.8 mm for the rest of the experiments. Photo 1 shows soybean meal.

Figure 2 Collected soybean meal put in an oven for drying

2.2.3. Physicochemical characterization

The parameters evaluated are recorded in Table 1 indicating the standards and protocols used to achieve our research objectives.

Table 1 Standards and protocols of the physicochemical parameters used

Settings	Standards/ References
Dry matter	NF V 03-909 (1988)
Ash content	NF V 03-909 (1988)
Fiber Content (Cellulose, Hemicellulose and Lignin)	TAPPI T 204; TAPPI T 222;[10]
Total nitrogen content	EN ISO 5983 (2005)
fat content	EN ISO 659 (1998)
Mineral elements (Calcium, Magnesium and Phosphorus)	[11]

3. Results and discussion

The results we achieved are as follows:

3.1. Physicochemical characteristics of pineapple peels

Figure 1 presents the physicochemical characteristics of the pineapple peels used in our study. From the results obtained, it appears that the dry matter content obtained (15.46 ± 0.39%) is in line with the work in the literature [7, 12, 13] which report values between 15 to 15.3%. The ash contents (3.5 ± 0.41%) are in agreement with those of previous work (3 to 3.7%) [14, 15]. The fat content 2.38 ± 0.09% is slightly higher than those reported by previous studies [7, 16, 17] which showed values between 1.18 and 1.19%. The total nitrogenous matter obtained 6.86% is consistent with that reported in the literature [12, 18, 17] (6.12 and 6.6%) but much higher than some works [14, 15, 16, 19] giving values between 3.5 and 5.08%.

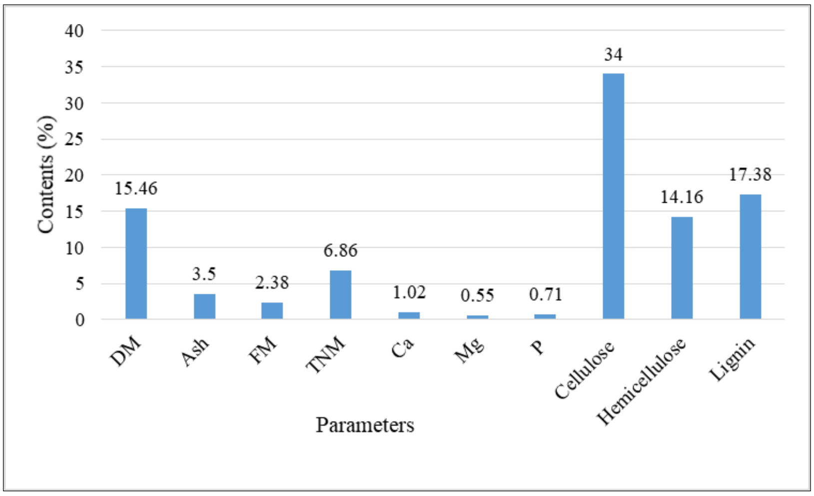
The calcium content (1.02%) found corroborates that of the literature [12, 18] (1.09%) and higher than that of [16] (0.18%). The magnesium content (0.55%) agrees with those reported by previous work [12] (0.42%). The phosphorus content (0.71%) is higher than those reported by the work of [12, 18, 16] who found values between 0.10 and 0.12% but lower than that obtained by [14] (1.5%). All these values are in line with the literature except for the fat content which is slightly higher in our study. This increase is due to the variety of fruits from which our pineapple peels are made.

Regarding fibers, the results show that pineapple peels are rich in fermentable sugar with a value of 34% for cellulose; 14.16% for hemicellulose and 17.38% for lignin. The value of cellulose obtained in our study is higher than those of studies conducted by some authors [13, 20, 21] which reported values between 21.98 and 25.18%. The hemicellulose content 14.16% is higher than those reported in the literature[7, 13] which shows values ranging from 7.44% to 8.77% but lower than the studies carried out by [19, 20, 21, 22] who found values between 22.4 and 74.96%. The lignin content 17.38% is lower than that reported by [20] which found 22.67% but higher than those of studies of [13, 7] who found 11.60 and 11.41% respectively.

The differences observed in terms of fiber content can be explained by the diversity of the edaphic characteristics of the soils from which the fruits used come. Added to this are other factors such as the variety of pineapple and the climatic conditions of its environment. However, the fiber contents obtained prove that pineapple peelings constitute a credible biomass for use in animal feed.

Indeed, with a rate of 34%, cellulose constitutes the majority compound to the detriment of hemicellulose and lignin. These are carbohydrate compounds that provide energy. Its fraction being more than twice as large as that of hemicellulose, its hydrolysis should provide glucose after digestion in animals.

It emerges from these results that the pineapple peelings are rich in fibers with a rate of cellulose equal to 34% which is a source of energy but poor in total nitrogenous matter and minerals. It will be necessary to mix the pineapple peelings with a protein source for the feed formulation, which justifies the choice of soybean meal. The latter constitute a local resource rich in protein 30 to 50% of the dry matter [23] and accessible.



DM: Dry Matter; FM: Fatty Matter; TNM: Total Nitrogenous Matter; Ca: Calcium; Mg: Magnesium; P: Phosphorus

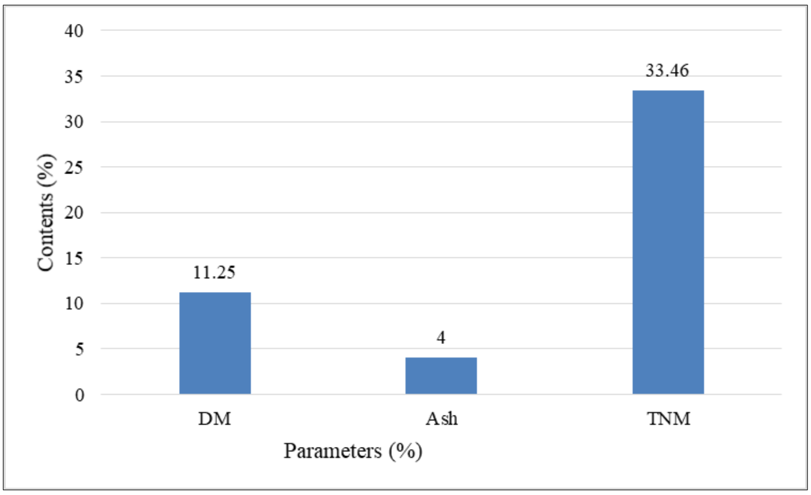
Figure 3 Contents of the different parameters analyzed on pineapple peels

3.2. Physicochemical characteristics of soybean meal

The result of the physical and chemical characterization of this biomass is recorded in Figure 2. From the analysis of this figure, it emerges that the soybean meal constitutes a source of dry matter (11.25 ± 0.10%); which is consistent with the literature [24] (11.28%). The ash content obtained in our study (4%) is lower than that reported by some works. [24] (6.93%).

As for the total nitrogenous matter, we found 33.46%. This rate is lower than those reported by [24, 25, 26] which found values between 45 and 48 % but respects the constraint found by other studies [23] (30 to 50% DM). This difference in total nitrogenous matter could be due to the edaphic characteristics of the soil where our soybean and its variety come from. In view of these results, we can say that soybean meal can be used as a source of protein.

We note that with a cellulose content of 34%, pineapple peels are a good source of energy but low in total nitrogenous matter and minerals for feed production. This deficit is corrected by the addition of soybean cakes having a content of 33.46% in total nitrogenous matter in order to provide a source of protein in the formulation.



DM: Dry Matter; TNM: Total Nitrogenous Matter

Figure 4 Contents of the different parameters analyzed on soybean cakes

4. Conclusion

This study was devoted to the recovery of pineapple peelings which constitute pollutants for the environment in animal feed (especially ruminants). It initially consisted in characterizing the pineapple peelings which were collected from one of the local fruit juice production structures. This characterization revealed that this waste contained a sufficient quantity of cellulose (34% DM) but low in total nitrogenous matter (6.86% DM). A second waste was therefore identified and characterized. These are soybean cakes with no commercial value. The characterization of the latter showed that they contain 33.46% of total nitrogenous matter, sufficient for animal feed.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors agree no conflict of interest.

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