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Chemical Characterisation of the Industrial Residues of the Pineapple (*Ananas comosus*)

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Abstract

In Mexico pineapple processing produces industrial residues with a high concentration of dietary fibre. The aim of this study was to quantify the constituents of the fibrous residues from the industrial processing of pineapples which exhibited low concentrations of lignin.

Keywords

Pineapple; Total Dietary Fibre; Hemicelluloses; Cellulose; Lignin; Pectin

1. Introduction

Pineapple (*Ananas comosus*) is native to the South American continent and is considered an exotic fruit due to its taste and flavour. In Mexico, pineapple cultivation has a long tradition and is of vital economic and cultural importance [1]. Mexico is the seventh largest producer of pineapples worldwide. Pineapple residues can account for 50% of waste weight and generate approximately 10 tons/year of fresh fibre. Larrauri *et al*. reported that the external part of the pineapple has a significant content of soluble carbohydrates (as the product of the pulp remaining after removal of the edible part) including more than 20% total dietary fibre (TDF), composed mainly of hemicellulose.

The residual lignocellulosic fibres are polymeric materials of great industrial interest, because they are renewable and biodegradable products. Their chemical composition depends on the type and origin of the fibres which contain different amounts of cellulose, hemicellulose and lignin (dietary fibre). In addition to the amounts of dietary fibre present in the plant tissues other important aspects but also their chemical (degree of lignification, type and crystallinity of cellulose) and physical (particle size and shape) properties, because these affect fermentation in the colon as well as the speed of transit in the gastrointestinal tract.

Toward this objective, these residues were grouped as the leaf bracts, shell and core for a study of relationship between the native cellulose phases.

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2. Materials and Methods

2.1. Raw Materials: Treatment and Classification

The residues were dehydrated in a horizontal drying chamber (Lumisell, Mexico, Mexico) at 60˚C moisture content was less than 10%.

2.2. Proximate Chemical Analysis of Raw Materials

Proximate chemical analysis for pulp and residues (leaf bracts, shell and core), was performed using the Association of Official Analytical Chemists (AOAC) [2]. The total protein was determined [% N × 6.25] using method 993.19; total ash using method 955.04; crude fat using (method 920.39), moisture content using method 934.01, crude fibre using the acid-alkaline hydrolysis method 991.42, carbohydrates were determined (by subtration as the nitrogen-free extract, NFE).

The Insoluble (IDF) and soluble (SDF) dietary fibre contents were determined according to the AOAC method. The samples were dried, defatted and freed from carbohydrate, before the analysis. The (TDF) contents were corrected for residual protein, and ash. The total dietary fibre content was calculated as the sum of IDF and SDF.

Total dietary fibre (method 991.43) was performed according to the technique described in AOAC [2]. The samples were dried, defatted and free of carbohydrate. It was run blank through entire procedure along with samples to measure any contribution reagents to residue. In triplicate, 1 ± 0.1 g of sample were suspended en 50 mL of phosphate buffer pH 6.0; submitted to enzymatic hydrolysis by 50 µL of heat stable α-amylase (A-3306, Sigma Chem. Co. St. Louis MO, USA) in boiling water bath for 30 min. After cooling suspension to room temperature, pH was adjusted to 7.5 ± 0.1 and 100µL of protease (P-3910, Sigma Chem. Co. St. Louis MO, USA) was added and left to in water bath at 60˚C for 30 min. After cooling pH was adjusted to 4.5 ± 0.1 and 300 µL of amyloglucosidase (A-9913 Sigma, Chem. Co. St. Louis MO, USA) were added.

The suspension was left to in water bath at 60˚C for 30 min. After that it was filtered to obtain the supernatant and the insoluble fraction. The supernatant was precipitated with 95% alcohol to precipitate the SDF and it was quantified by drying overnight at 105˚C. The insoluble fraction was washed with 78% and 95% alcohol solutions and acetone, respectively, followed by drying overnight at 105˚C to obtain the IDF. The dietary fibre contents were corrected for residual protein, ash and blank. The total dietary fibre was indicated as the sum of IDF + SDF.

To quantify the content of hemicellulose, the method for the determination of the neutral detergent fibre (NDF) content was used as described previously by Van Soest [3]. Consequently, this residue of this analysis was utilized to determine the content of cellulose and lignin called the acid detergent fibre (ADF), using method 973.18.

2.3. Statistical Analysis of Data

An analysis of variance was used applying Tukey's test ($\alpha = 0.05$) utilizing Statistical Analysis System 8.0 (SAS Institute Inc., Cary, North California, USA) software [4].

3. Results and Discussion

In **Table 1** the proximate chemical composition of the pineapple pulp and residues (leaf bracts, shell and core) are shown. Statistical analysis revealed significant differences ($p \leq 0.05$) in the parameters total protein, ash and crude fat values. The total protein content ranged from 0.7 g/100g of leaf bracts to 1.58 g/100g of pulp; this total protein could be mainly attributed to hydroxyproline-rich glycoprotein, Because Bartolome and Ruperez [5] and Smith *et al*. [6] reported that the glycoproteins in the shells of fruits, are immersed in the primary cell wall forming a network of microfibrils with the cellulose [7]. The leaf bracts exhibited the highest ash content, which was twice that in the pulp; although the values reported by Chau and Huang [8] in orange peels (3.3 g/100g) are twice those of the pineapple's shell and core. One important consideration is that carbohydrate content was determined by calculation and may include simple sugars such as monosaccharides and disaccharides [9]. The highest content of crude fat was found in the edible fraction of the pulp, followed by the core (in the case of the residue), whereas the lowest concentration of crude fat was in the leaf bracts.

Table 1. Proximate chemical composition of the residues pineapple (leaf bracts, shell, and core) compared with pulp of pineapple.

(g/100g)	Pulp	Leaf bracts	Shell	Core
Total protein	1.58 ± 0.01[d]	0.70 ± 0.01[a]	0.75 ± 0.01[b]	0.85 ± 0.01[c]
Ash	3.0 ± 0.01[b]	7.37 ± 0.0[d]	1.5 ± 0.00[b]	1.3 ± 0.00[a]
Crude fat	3.19 ± 0.00[b]	3.5 ±.01[c]	2.0 ± 0.01[a]	3.17 ± 0.01[b]
Crude fiber	24.14 ± 0.01[a]	62.5 ± 0.00[c]	65 ±0.00[c]	47.6 ± 0.00[b]
NFE*	68.79 ± 0.00	25.93 ± 0.02	32.1 ± 0.02	47.08 ± 0.01

*NFE = Nitrogen-free extract. Results are given for dry basis and correspond to the average from three independent determinations ± standard deviation. Different letters in the same row indicate statistically significant difference ($p \leq 0.05$) after applying Tukey's test.

Table 2. Comparison of the chemical composition of the pineapple residues (g/100g Dry weight).

Fibre	Leaf bracts	Shell	Core
IDF	43.53 ± 0.93[a]	46.20 ± 0.50[b]	42.92 ± 0.09[a]
SDF	29.16 ± 0.46[b]	35.67 ± 0.37[c]	21.27 ± 0.61[a]
TDF	74.69	81.8	64.19
Hemicellulose	21.88 ± 0.22[a]	28.69 ± 0.35[b]	28.53 ± 1.37[b]
Cellulose	43.53 ± 1.17[c]	40.55 ± 1.02[b]	24.53 ± 1.68[a]
Lignin	13.88 ± 1.70[c]	10.01 ± 0.38[b]	5.78 ± 0.429[a]
Pectin	2.32 ± 0.37[b]	2.49 ± 0.20[b]	1.58 ± 0.17[a]

3.1. Proximate Chemical Analysis

The raw fibre contents ranged from 24.14%, in the pulp, to 65%, in the leaf bracts. As shown in **Table 1**, the raw fibre content of the residue fraction is 2.5 times greater than the edible fraction (pulp); these values are similar to those found by Larrauri *et al*. [10] and, Bartolome and Ruperez [5] who also studied pineapple shells.

3.2. Determination of Soluble (SDF) and Insoluble (IDF) Dietary Fibre

Table 2 shows the results obtained for the different dietary fibre fractions, the statistical analysis showed that significant differences ($p \leq 0.05$) exist among the leaf bracts, shell and core.

The content of dietary fibre (TDF) in the residue depended on the source from which it was extracted, with the shell having the highest content (81.8 g/100g of dry sample). This value is higher than that reported by Chau *et al*. [8] for orange residues and by Figuerola *et al*. [11] for grape peels.

Results are given for dry basis and correspond to the average from three independent determinations ± standard deviation. Different letters in the same row indicate statistically significant difference ($p \leq 0.05$) after applying Tukey's test.

Furthermore, the main fibre fraction found in the residues studied fibres was the (IDF fraction) which represented 56% - 65% of the TDF, similar to the value reported for orange peel [11], but greater than that reported for grape peels [9]. These results indicated that the samples tested were composed mainly of cellulose microfibrils containing hemicellulose and lignin [12], as shown in **Table 2**.

4. Conclusion

The agroindustrial pineapple residues had a greater fraction of fibre than the edible portion or pulp, and even more than other agroindustrial residues. The amount of dietary fibre found in the pineapple leaf bracts, shell and core residues, was relatively high and with the insoluble fraction being the main component.

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