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Characterisation and potential application of pineapple pomace in an extruded product for fibre enhancement

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ABSTRACT

This study characterised pineapple pomace (PP) and evaluated its application in extrusion to enhance fibre content of the final product. The pomace had low fat (0.61%) and high dietary fibre (45.22%), showing its potential for fibre enrichment of nutritionally poor products, as some extruded snacks. Results also showed low microbiological counts, water activity, and pH indicating good microbiological quality and low risk of physicochemical deterioration. During extrusion, pomace (0%, 10.5% and 21%), moisture (14%, 15% and 16%) and temperature (140 and 160 °C) were evaluated. The PP addition decreased expansion and luminosity; while increasing redness of the extrudates compared to the control (0% pomace/14% moisture/140 °C). When hardness, yellowness, water absorption, and bulk density were compared to the control, there was no effect ($p > 0.05$) of 10.5% PP addition on the extrudates, indicating that, at this level, PP could be added without affecting the properties of the final extruded product.

1. Introduction

Pineapple world production reached 21.8 million of tons in 2011 (FAO, 2013), and most of its production is used for processing as fruits salads, juices, concentrates, and jams. During processing, large amounts of byproducts, consisting mainly of peel and pomace are generated, representing about 25–35% of the fruit weight (Larrauri, Rupérez, & Calixto, 1997). Since most of these byproducts have no specific destination, they may be inappropriately disposed causing environmental issues. Consequently, it is of vital importance to reuse industrial byproducts in order to improve the process economics and its sustainability.

It is well-known that dietary fibre plays an important role in human health, promoting several physiological and metabolic positive effects (Raninen, Lappi, Mykkänen, & Poutanen, 2011). The insoluble dietary fibre acts as a bulking agent, normalising intestinal motility, preventing constipation while soluble fibre is associated to decreasing the intestinal absorption of cholesterol and glucose (Rodríguez, Megías, & Baena, 2003). Due to all of these benefits of dietary fibre intake, a tendency in the development of products enriched with fibre or with specific fibre claims has already been observed for some time. According to the Food and Drug Administration (FDA) (2013), to have a product with a "high source of fibre" and "good source of fibre" claim, it must contain, respectively, 20% or more fibre and 10–19% of fibre of the recommended daily value for dietary fibre in a serving size.

About 76% of pineapple byproduct (peel and heart) is fibre, from which 99.2% is the insoluble fraction and 0.8% is the soluble fraction (Martínez et al., 2012). As pineapple pomace contains valuable sources of dietary fibre, they could be used as a potential food ingredient to improve nutritional quality of foods. Furthermore, fibres have technological properties, such as water holding capacity (WHC), swelling capacity (SWC) and oil holding capacity, which can be useful in products that require hydration, to avoid syneresis, improve yield, stabilize high fat food products and emulsions, and also to modify texture and viscosity (Elleuch et al., 2011). One alternative would be to use these byproducts as ingredients in selected food process, i.e. extrusion processing.

Extrusion is an attractive choice because its versatility (wide range of food products applications), high productivity, relative low cost, energy efficiency and lack of effluents (Altan, McCarthy, & Maskan, 2008). Furthermore, extrusion-cooked products tend to be nutritionally poor since they are energy dense, and low in health promoting ingredients. The extrusion process itself

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promotes the depolymerisation of the starch, leading to an increase in the amount of easily digestible carbohydrates and resulting in a product with high glycemic index (Brennan, Derbyshire, Tiwari, & Brennan, 2013a).

Due to the characteristics of these products, some studies have evaluated the addition of food processing byproducts in extruded foods as source of fibre and bioactive compounds. The byproducts include orange peel, grape seed and tomato pomace (Yağcı & Göğüş, 2008); a mixture of cauliflower florets, curd, stem and leaves (Stojceska, Ainsworth, Plunkett, İbanoğlu, & İbanoğlu, 2008); and carrot pomace (Kumar, Sarkar, & Sharma, 2010). The addition of these byproducts promoted some alterations in the characteristics of the extrudates, but in all of the studies, good sensory acceptance was observed. Brennan, Derbyshire, Tiwari, and Brennan (2013b), used β-glucan rich materials from mushroom and barley processing as ingredients in extruded snacks and reported that the inclusion of this fibre promoted a reduction in the glycemic response.

Since pineapple processing produces significant amount of fibre rich pomace and currently there is lack of studies about its application in extruded products, the use of this byproduct in extrusion would be an interesting option as fibre enrichment. Besides, it would benefit the pineapple processing operations by making them more economically sustainable. Thus, the objective of this study was to characterise and evaluate the performance of pineapple pomace as an ingredient in extruded products.

2. Materials and methods

2.1. Production of pineapple pomace

Three different batches of mature pineapple (*Annanas comosus*), variety Gold (Del Monte Gold, Costa Rica), were purchased from local stores in Lincoln, NE, USA, during September 2012. To produce the byproduct, referred herein simply as pomace, fruits were processed at The Food Processing Center Pilot Plants of the University of Nebraska-Lincoln. First, the fruits were sanitized with 200 ppm of sodium hypochlorite, rinsed with water, and cut by hand into small pieces with peel. The pieces were introduced in a juice extractor (Speed Troll, Sterling Electric Inc., Irvine, CA, USA), where the juice was expelled and the pomace collected. The pineapple pomace (PP) (peel and pomace) was freeze-dried (Thermovac, Long Island, NY, USA) for 72 h under vacuum condition, ground using a knife mill (Mini Mill, Thomas Wiley, Swedesboro, NJ, USA), passed through a 40-mesh stainless steel sieve (420 μm), and stored into sealed plastic containers at −20 °C for further analyses. The particle size of these samples (Table 1) was determined in triplicate by laser diffraction in a Malvern Mastersizer 3000 (Malvern Instruments, Worcestershire, UK), using the dry dispersion method (Aero S dispersion cell), with a refractive index of 1.53, an air pressure of 4 bar and a sample feed of 50%.

Table 1
Particle size distribution of freeze-dried pineapple pomace (Average ± SD).

Size (μm)	% Undersize particles*
211	48.94 ± 2.13
454	87.13 ± 0.30
666	97.06 ± 0.38
859	99.05 ± 0.43
1110	99.51 ± 0.36
3080	100.00 ± 0.00

* Percentage of particles with diameter under the size (μm) described in the first column of this table.

2.2. Characterisation of pineapple pomace

2.2.1. Chemical analyses

Ash was determined according to AOAC 940.26 ((2000)), using a Thermolyne 30400 Furnace (Thermo Scientific, Waltham, MA, USA). Moisture was determined using a vacuum Thermolyne Oven Series 9000 (Thermo Scientific, Waltham, MA, USA) following AOAC 924.06 (2000). Soluble (SDF) and insoluble dietary fibre (IDF) were determined according to AOAC 960.52 (2000). Protein was calculated from the nitrogen content by the Dumas combustion method (Leco FP-528, Leco Corporation, St. Joseph, MI, USA) using a conversion factor of 6.25 and fat was determined by the Soxtec method (Soxtec 2043, Foss, Hillerød, Denmark), both according to the manufacturer's instructions. Carbohydrate content was calculated by difference. The analyses were carried in triplicate.

2.2.2. Physicochemical analyses

The pH of the samples was measured in a suspension obtained from a blend of 10 g of sample with 100 mL of deionised water, using a pH metre (Orion 2 Star, Thermo Electron Corporation, Beverly, MA, USA). Acidity was determined by titration with 0.1 N sodium hydroxide and the results were reported as g of citric acid/100 g of sample. Water activity (Aw) was determined using an Aqualab instrument (Aqualab Series 3TE, Decagon devices Inc., Pullman, WA, USA) at 25 °C. Colour was measured with a colorimeter (Minolta CR-300, Konica Minolta, Osaka, Japan), with D65 as illuminant, based in the CIELAB L^*, a^*, b^* colour space. The instrument was calibrated using a colour standard (white), with $Y = 92.7$, $x = 0.3162$ and $y = 0.3325$, provided by the manufacturer. Colour readings were taken in different points on the surface of the byproduct powder. The analyses were carried in triplicate.

2.2.3. Functional properties

Water holding capacity (WHC) and oil holding capacity (OHC) were determined in triplicate by the method described by Carcea-Bencini (1986), with the following modifications. One gram of pomace sample was stirred in 10 mL of distiled water (for WHC) or canola oil (Pure Wesson, ConAgra Foods, Omaha, NE, USA) (for OHC), centrifuged (Sorvall Legend XTR Thermo Scientific, Waltham, MA, USA) at 2200*g* for 30 min and the supernatant was carefully eliminated. Water holding capacity was reported as the number of grams of water held by 1 g of sample and oil holding capacity was reported as the number of grams of oil held by 1 g of sample.

2.2.4. Microbiological analysis

Microbial counts were determined by diluting 25 g of sample in 225 mL of phosphate sterile buffered peptone water (BPW) (Acumedia, Lansing, MI, USA) to achieve the 1:10 dilution. Following dilution, samples were blended using a Stomacher (Seward Laboratory Systems, Bohemia, NY, USA), for 1 min. Further serial dilutions were prepared in BPW for all of the microbial determinations. Total plate counts (TPC) were determined by plating the diluted samples on APC Petrifilm plates (3 M, St. Paul, MN, USA) followed by incubation at 35 °C for 48 h. *Escherichia coli* and thermotolerant coliforms were counted by plating samples on *E. coli*/coliform petrifilm plates (3 M, St. Paul, MN, USA) following incubation at 45 °C for 24 h. Molds and yeasts counts were determined after plating samples on Dichloran Rose Bengal Chloramphenicol agar (DRBC) (Acumedia, Lansing, MI, USA) and incubating at 25 °C for 5 days. All these determinations were carried in duplicate for each dilution. *Salmonella* testing was performed by a pre-enrichment with BPW at 37 °C for 24 h, followed by a selective enrichment step with Tetrathionate Broth (TTB) (Acumedia, Lansing, MI, USA) at 41 °C for 24 h. Enriched samples were then