From residue to value product: the use of apple pomace for a diet rich in fibre

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Eat more fibre. You have probably heard it numerous times. But why? Because general consumption of dietary fibre can reduce the risk of coronary heart disease, stroke, hypertension, diabetes, obesity, and gastrointestinal diseases [1].

Recommended dietary fibre intake is between 25 and 30 g per day for a healthy adult in New Zealand, but total fibre consumed is only around 70% of that [2]. Some companies are seeking to exploit this gap, and are looking for natural fibre sources, especially locally.

Apple pomace is a potential source of fibre. In 2016 New Zealand made about 10,000–15,000 MT of apple pomace as a by-product of juicing [3]. Its high moisture content makes pomace bulky, hard to handle and prone to microbial decomposition. Disposal is difficult and can be costly. From a nutritional point of view, the dietary fibre of apple pomace contains a good balance of soluble and insoluble fibre [4]. It also contains polyphenols, carotenes and flavonoids [5, 6], making pomace a candidate ingredient for nutritional foods.

Scope of research

A research team from Massey University and Plant and Food Research is developing a process to convert apple pomace into a fibre-rich food ingredient that can impart creamy textural properties to food products. We aim to break up cell wall material into suitable fragments and envelope these in extracted pectin. We hope for synergy between insoluble and soluble components.

A desirable process is one that will arrest enzymatic and microbial degradation of pomace within seconds of that pomace being generated. We must remove pips, labels, stalk and skin. We want to extract pectin, break it down slightly and then break the insoluble mass up into individual soft cell remnants. We want to do all this at 100% yield and render the product to a stable concentrate or powder. Economically.

Ideally, all these things will be achieved in as few process steps as possible with very simple equipment. We envisage a hydrothermal treatment, a shearing treatment and a concentration stage before packing.

The research involves understanding each of these three treatments well enough to design the full-scale plant. We have identified each key reaction and measured the kinetics at lab scale. The resulting kinetic model lets us calculate likely performance at any scale – we are testing it first at small pilot scale.

Process

Hydrothermal treatment is environmentally friendly – it uses hot water but no other solvents. By tweaking temperature and time, we have a flexible and versatile process.

The hydrothermal operational conditions selected will be crucial for killing microorganisms, deactivating enzymes, degrading thermolabile compounds, solubilising components and modifying the cell wall structure. While heating can have beneficial effects on the food product by solubilising more pectin, prolonged heating can have undesirable effects on the appearance, flavour, colour, and nutritional value.

Pectin starts to solubilise at lower temperatures [7] than cellulose and hemicellulose [8]. Some pectin is solubilised at room temperature but this temperature is not sufficient to deactivate browning enzymes or reduce microbial load. Increasing the temperature or the holding time raises soluble pectin yield. This involves acid hydrolysis, β-elimination and demethylation reactions affecting molar mass and intrinsic viscosity and thence texture and mouthfeel. We desire controlled pectin release and want to avoid undue browning or furfural production.

If we can solubilise pectin, we reduce cell adhesion as a prelude to shearing. A shearing process implies particle size reduction by applying mechanical energy [9]. Several studies show that this modifies the particle morphology and the inter-particle interactions, increasing the viscosity or altering the textural properties. We expect rheological properties of our product to depend mainly on the soluble components in the liquid phase and on the volume fraction of insoluble solids.

As a final step in the process, the product will need to be heated once more to stabilise it before packaging.

Progress to date

We harvested fresh pomace from a major New Zealand juice company and froze samples in small lots until use – the composition is shown in Figure 1. We built 20 small batch reactors (capacity of 14 mL) for hydrothermal treatment and investigated the reactions between 90–140°C at 10°C intervals for up to 360 min. We analysed for sucrose, glucose, fructose, formic acid, acetic acid, furfural and 5-hydroxymethyl furfural. Other measurements included the amount of pectin solubilised, unsaturated uronides formed by β-elimination, reducing end groups formed by acid hydrolysis and the degree of pectin esterification. We identified the optimal temperature and time to obtain a high yield of solubilised pectin with minimal degradation products. Potential reactions involving pectin are shown in Figure 2 [10].

We subjected an optimally processed sample to shear treatments and then evaporated it under vacuum. Even before optimising these latter

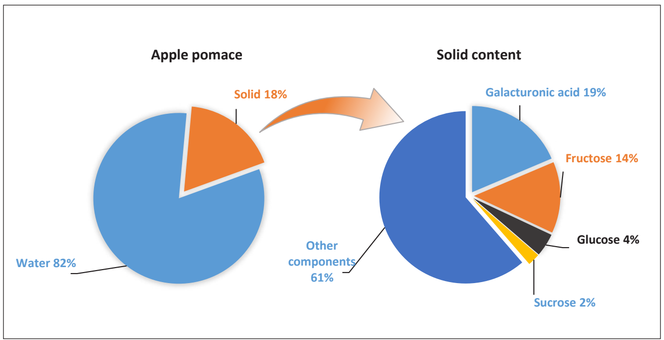

Figure 1. Composition of apple pomace

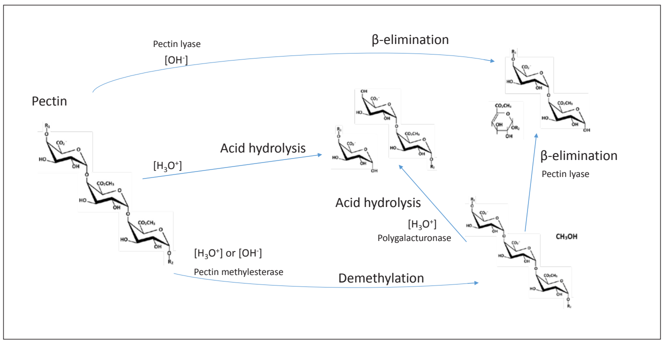

Figure 2. Simplified reaction pathway in pectin. Adapted from [10]

Figure 3. Hydrothermal treatment at lab scale (left) and pilot scale (right)