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Increasing functionality of apple products

Derek Keenan, Christian Roessle and **Ronan Gormley** report on a series of trials involving apple products as part of the European Union ISAFRUIT project to improve the profit margins and nutritional value of fruit

Apples are an inherently "functional", or healthy, fruit – as indicated by the age-old saying "an apple a day keeps the doctor away". Presumably this is at least in part because of the content of pectin (a dietary fibre that also reduces cholesterol), antioxidants, minerals, vitamins and other bioactives in apples. So why go any further?

The era of functional foods is upon us and consumers are becoming more aware of such foods. Food producers and processors are also facing tighter profit margins and added value is imperative. So, functional apple products may afford new opportunities for both producers and processors. This is why they are one of the research and development (R&D) topics at Ashtown Food Research Centre (AFRC) in Dublin, as part of the EU ISAFRUIT project (a European integrated research project).

The R&D at AFRC involves two streams: (i) adding bioactives (food components or dietary supplements, other than those needed to meet basic nutritional needs) to fresh-cut fruit salads with emphasis on apples; and (ii) adding bioactives/functional ingredients to processed apple products. The work will be extended to other tree fruits later in the project.

Above: Granny Smith slices infused with AS1; top: *sous-vide* cooking retains nutrients

EU ISAFRUIT project

The EU ISAFRUIT project (6th Framework Programme) embraces 200 researchers from 61 institutions, and also SMEs (small and medium-sized enterprises) in 16 countries. It began in January 2006 and will finish in mid-2010.

ISAFRUIT focuses on all aspects of tree fruit – from seed to consumption. The trials at AFRC involve "improved appeal and nutritional value of processed fruit". The slogan of ISAFRUIT is "healthy fruit for a healthy Europe". Teagasc, Ashtown and Nature's Best are its Irish partners and the project's website is www.isafruit.org.

Fresh-cut fruit salads with a shelf life of up to 10 days feature increasingly on supermarket shelves, and apple slices are often a major constituent of these salads. R&D to date at AFRC has focused on three aspects: (i) efficacy of a browning inhibitor for fresh-cut apple slices; (ii) preparation of apple slices containing a prebiotic and added calcium; and (iii) honeysweet apple slices, ie apples infused with honey.

Browning inhibitor

Enzymatic browning is a big problem in the production of fresh-cut apple wedges and permitted browning inhibitors are used. In this context, the efficacy of Natureseal AS1 (AgriCoat, UK) was tested as a prerequisite prior to infusing apple slices with bioactives or honey. Natureseal AS1 was applied as a dip at three concentrations (1.5, three and six per cent) and three dipping times (two, 60 and 120 minutes) to unpeeled wedges of Bramley's Seedling apples, which were then sealed in plastic trays with a breathing film and tested after seven days at 2-4°C. The results were compared with values for fresh-cut untreated samples (ie baseline values). Both concentration and soaking time in Natureseal AS1 influenced the white/yellow colour ratios (Hunter colour meter; high values best) of the wedges with day-seven ratios of 3.21, 3.44, 4.02 (two minutes in the 1.5, three and six per cent solutions respectively) compared with 2.86 for the undipped control.

The day-seven values compared with a white/yellow ratio of 5.73 in untreated fresh-cut wedges on day zero. This indicates that while not all of the original wedge whiteness was maintained by Natureseal AS1, it nevertheless had a strong protective effect on colour during the seven-day storage period.

The use of Natureseal AS1 did not influence the texture (shear values), soluble solids content, dry matter content, pH or the titratable acidity of the apple wedges. A dip regime of six per cent for two minutes was chosen for subsequent trials in order to maintain an acceptable level of whiteness coupled with a moderate level of AS1 in the apple wedges.

Apple slices with a prebiotic or algal calcium

This study aimed at further increasing the health profile of apple slices through vacuum infusion with soluble algal calcium (Aquamin Soluble, a highly available form of calcium from Marigot, Ireland, target 120mg/100g slices), or with an oligosaccharide (Beneo P95 from Orafti, Belgium, with a target of five per cent in the slices) which has prebiotic properties and is also a dietary fibre.

Oligosaccharides are obtained from inulin, which is found in chicory, Jerusalem artichokes and other plants. Prebiotics act as a feedstock for the beneficial bacteria in our gut, causing them to proliferate. Granny Smith apple slices (in the form of circles) were dipped in AS1 (six per cent, for two minutes), vacuum-treated for 20 minutes, transferred to a suspension of Aquamin Soluble (12 per cent, for 10 minutes), or to a solution of Beneo P95 (35 per cent, for 15 minutes) and then prepacked in clear trays. Physicochemical tests were conducted ▶

Emerging trends: convenience foods are a key driver of change in consumer markets, and the study sought to produce ready-made desserts using processed apple wedges/puree

on days zero and seven after storage at 2-4°C. The control was fresh-cut apple slices. Calcium content of the slices was measured by atomic absorption, fructose by gas chromatography, and oligosaccharide content of freeze-dried slices by Orafti. Sensory acceptability tests – zero (unacceptable) to six (very acceptable); 20 tasters – were conducted on the Aquamin Soluble and Beneo P95-treated slices.

There was an increase in soluble solids of 3.3 per cent (13.8 vs 17.1) between control (fresh-cut slices) and Beneo P95-infused samples due to uptake of Beneo P95. Apple weights in the trays were 198g after slicing, 185g after vacuum treatment, and 197g after infusion with the Beneo P95 solution. Fructose levels in the slices were 45.1mg/g (fresh-cut) and 48.7mg/g dry weight, indicating minimal breakdown of Beneo P95 under the acidic conditions prevailing in the slices.

This finding was confirmed by data for oligosaccharide content which showed values of 19.8, 19.5, 22.1 and 21.2 per cent (of dry weight) in four freeze-dried samples treated with Beneo P95, compared with less than 0.1 per cent in each of four control samples.

There was also a good uptake of Aquamin Soluble as indicated by a calcium content of 190mg/100g in the slices as eaten; this was well above the target value of 120mg. The slices containing Beneo P95 or Aquamin Soluble were downgraded in sensory tests as indicated by scores of 3.96 (fresh-cut control) vs 2.63 (Beneo P95), and 4.25 (control) vs 1.92 (Aquamin soluble). However, improved acceptability is anticipated with apple wedges.

Honeysweet apple slices

Honey and apples have a good health image and contain antioxidants. In addition, some apple cultivars such as Granny Smith benefit from sweetening, hence this trial on infusion of apple wedges with honey. Mexican and Argentinian honey samples (Boyne Valley Foods, Ireland) were used because of their strong flavour and dark colour, which is an indicator of antioxidant content.

Sets of Granny Smith wedges pretreated with Natureseal AS1 (six per cent solution, for two minutes) were submerged on day zero in 50 per cent honey solutions in a vacuum tumbler (in stationary mode); a separate sample was infused with water. The samples were prepacked in trays, and sensory acceptability was assessed on day one and physicochemical properties on days one and seven after storage at 2-4°C. (see table, below).

The infusion process used was successful in that soluble solids and dry-matter content values increased by three to five per cent in the honey-treated samples relative to the control.

However, there was no weight change on infusion with honey solution. This suggests that water was removed from the wedges and that solutes (honey sugars) penetrated the wedges in quantity during the infusion process. This was confirmed by spot taste tests, which indicated a strong honey flavour throughout the wedges and not just at the surface.

By contrast, there was a large weight gain in the water-infused samples due to water uptake and reduced soluble solids and dry-matter content. Wedge whiteness values fell with the treatments but the lower values obtained were due to a slight translucency. The treated wedges were also softer than the fresh-cut samples. Sensory acceptability scores were lower for the treated samples than for the fresh-cut ones, especially the sample infused with water.

Effect of vacuum infusion with 50 per cent honey solutions or with water on a range of quality parameters of Granny Smith apple wedges

Parameter	Argentinian honey	Mexican honey	Water	Control*
Weight change (%) on infusion	−0.36	−0.29	28.3	Not infused
Soluble solids (%)	17	15.3	8.4	11.8
Dry matter content (%)	18.6	17.2	10.1	13.6
Whiteness (Hunter L)	56.1	50.7	41.3	75.1
Texture (shear; kN)	2.63	2.24	2.47	2.95
Titratable acidity (mEq/100g puree)	8.4	8.6	7.3	8.6
Sensory acceptability (0-6)	2.82	3.36	2.01	4.14

**Fresh-cut untreated sample*

Tests on apple products as ready desserts

Changes in lifestyle have resulted in an increased demand for convenience foods, and convenience remains the major driver of change in consumer markets. Despite the prominence of ready-meals in retail outlets, ready-desserts are only an emerging feature. Most of them are rich in dairy or cereal components and low in fruit. The emphasis

here is to reverse this trend, ie to produce ready-desserts rich in fruit with a minimum or no dairy content.

This series of trials involved the inclusion of functional ingredients in Bramley's Seedling apple products (wedges or purees) processed by stewing or microwaving (depending on the application), followed by chilling or freeze-chilling. Other sample sets were processed by *sous-vide* cooking (without air) involving sealing raw or partially cooked apple pieces in a vacuumised plastic pouch, cooking by controlled heating, followed by rapid chilling and subsequent reheating for consumption.

The term "freeze-chilling" is used to describe the process of freezing followed by tempering and storage at 2-4°C, ie the consumer sees the product as a chilled item. Freeze-chilling provides logistical and reduced product-recall benefits, while *sous-vide* prevents growth of *Clostridium botulinum* spores and gives products of high sensory quality with good nutrient and colour retention due to the gentle cooking regime (Barriquand Steriflow retort) and the absence of oxygen.

Three functional ingredients were added individually to the Bramley product range: (i) Beneo HSI (addition rates zero, three and eight per cent of apple puree/wedge weight); (ii) alcohol insoluble solids (AIS) (addition rates zero, five and 10 per cent); or (iii) three apple pomaces (Alpex with seeds, Alpex without seeds, and pomace from the cultivar 'Shampion'; addition rates zero, 2.5 and five per cent for each).

Beneo HSI is a prebiotic, a dietary fibre and a sweetener; the AIS is dietary fibre powder prepared from Bramley's Seedling apples and has cholesterol-lowering properties; while the pomaces (supplied by Polish partners in the ISAFRUIT project) are dietary fibre concentrates (up to 50 per cent fibre) and contain antioxidants.

Sensory and physicochemical tests on the product range indicated that apple products with Beneo HSI were well-liked, probably due to the sweetening effect of Beneo HSI. Addition levels above five per cent (for AIS) and 2.5 per cent (for the pomaces) resulted in product-downgrading by taste panelists due to grittiness. This effect may be overcome by grinding the AIS and pomaces to a finer particle size. The higher inclusions of AIS or pomace also resulted in thickening of the processed apple products as indicated by texture profile analysis. Pomace from 'Shampion' apples was the best of the three pomaces tested as it has a white colour (low browning tendency) and did not detract from apple puree or wedge colour.

Future of functional fruit

- Functional fresh-cut apple slices suitable for fruit salad applications were produced containing a prebiotic and available calcium. The infusion process needs further refining and this will be conducted in association with an SME. Future trials will also focus on infusing apple slices with probiotics.
- Honeysweet apple slices were satisfactorily produced by a vacuum infusion process. However, the procedure needs fine-tuning. Tests will be conducted on the antioxidant status of the honey used and also of the infused apple slices.
- Functional (healthy) processed apple wedge/puree ready-desserts containing a range of functional ingredients were produced from Bramley's Seedling apples. These trials are continuing, using a range of apple cultivars and also a number of accompaniments (creams, artificial creams, custards).

The techniques used above for fresh-cut apples and processed apple products will be applied to other tree fruit later in the ISAFRUIT project.

Derek Keenan and Christian Roessle are PhD students and Ronan Gormley is a senior principal research officer at Ashtown Food Research Centre, Dublin, where this research was conducted. *The European Commission is gratefully acknowledged for part-funding the R&D described above as a component of the ISAFRUIT integrated 6th Framework Programme.* *For more information contact ronan.gormley@teagasc.ie.*