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Fruit, Health and the Consumer: **Outcomes from ISAFRUIT Fruit** **Forum Conference**

18 May 2010

Editors:

Ronan Gormley

UCD Institute of Food and Health, University College Dublin,
Belfield, Dublin 4, (e-mail: ronan.gormley@ucd.ie)

Nigel Brunton

Teagasc Food Research Ashtown, Dublin 15,
(e-mail: nigel.brunton@teagasc.ie)

The **ISAFRUIT FRUIT FORUM CONFERENCE** was a joint initiative between Teagasc Food Research Ashtown (TFRA), UCD Institute of Food and Health (UCD-IFH), and the EU ISAFRUIT 6th Framework Integrated Project in association with Bord Bia and the RELAY Dissemination Project. The event was held in the Training Centre at TFRA.

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INTRODUCTION

The overall theme of the Fruit Forum Conference was **BETTER FRUIT for the CONSUMER** and the focus was on bringing together the various ‘actors’ in the fruit chain to interact and discuss the health aspects of fruit as well as recent developments in fruit storage, consumer preferences, and sourcing and retailing aspects. The morning session dealt with the **health benefits** of fruit, and also new generation fruit products such as fresh-cut apple slices with pre- and pro-biotics, heat-processed fruit puree products with pre-biotics and antioxidant dietary fibres. The afternoon focused on aspects relating to **consumers** including new developments in fruit sourcing and retailing, and on consumer preferences for apples and other fruit. The morning session was chaired by **Paula Mee** of *Nutrition Consulting*, and the afternoon by **Mike Neary** of *Bord Bia (Irish Food Board)*. The morning and afternoon sessions concluded with two fora (Fruit for Health and Fruit Market Place) comprising the speakers, the chairpersons, and two additional experts, i.e.

The targeted audience included health professionals; fruit producers; fruit processors; fruit distributors; retailers; horticultural advisors; 3rd level institutions; Food Safety Authority of Ireland; Bord Bia; Enterprise Ireland; personnel from Government Departments and consumer organisations; 75 persons attended.. Much of the proceedings were video recorded (by Ashley Pollak, UK) and edited highlights are on the ISAFRUIT project website (www.isafruit.org).

The Fruit Forum Conference was held under the auspices of the EU 6th Framework ISAFRUIT Integrated Project. ISAFRUIT commenced in January 2006 and concludes in September 2010. ISAFRUIT has circa 200 researchers in 61 institutions (Partners) in 16 countries and has also some SMEs participants. The two Irish partners are Teagasc Food Research Ashtown and Nature’s Best Ltd. The overall budget is €21.4 million (€13.8 million from EU). ISAFRUIT focuses on all aspects of tree fruits from seed to consumer and its strategic objective is ‘healthy fruit for a healthy Europe’.

ISAFRUIT is organised around seven knowledge Pillars: (i) consumer driven & responsive supply chain; (ii) fruit & human health; (iii) improved appeal & nutritional value of processed fruit; (iv) improved quality, safety & sustainability; (v) pre-harvest chain quality & sustainability; (vi) genetics of fruit quality; (vii) dissemination & transfer of knowledge.

This publication contains synopses of the presentations and also some outcomes from the two discussion fora including a consensus statement from each.

SECTION 1: FRUIT FOR HEALTH

Fruit for health: Laboratory & clinical trial outcomes on fruit

Lars Dragsted (University of Copenhagen, Denmark) & Ronan Gormley (UCD Institute of Food and Health, University College Dublin, Dublin 4)
e-mail: ldra@life.ku.dk
e-mail: ronan.gormley@ucd.ie

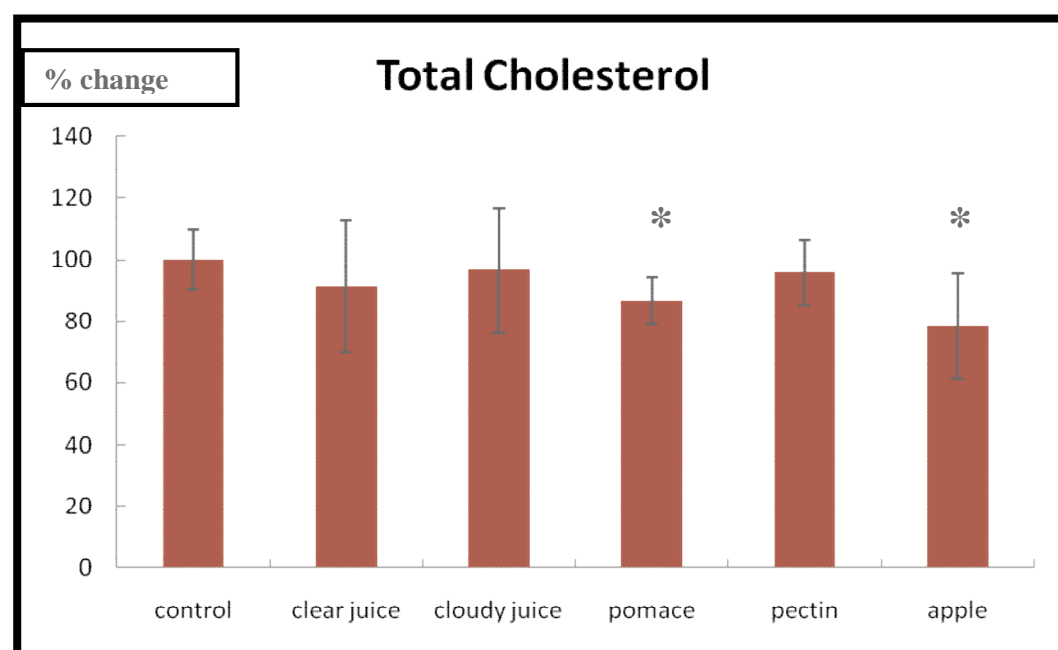
Introduction

Observational studies and meta-analyses on fruit have indicated that each daily serving of fruit (and/or vegetables) is associated with a decreased risk of cardiovascular disease (CVD) of 4-11%. Epidemiological studies have indicated that high intakes of fruit & vegetables are associated with a reduction in the incidence of heart disease, stroke, cancer, cataracts and other conditions. This raises the question as to why fruit & vegetables are healthy dietary options, e.g. (i) which bioactive component(s) are responsible for the positive health effect, and (ii) what are the functional mechanism(s) behind their action? Some bio-active components in fruit are small molecules including antioxidants (nutrients and non-nutrients); anti-inflammatory compounds; enzyme inducers and plant sterols. Others, e.g. dietary fibre components are large molecules/polymers and include soluble fibres (e.g. oligosaccharides and pectins,), cell wall components (largely insoluble) and resistant starch.

ISAFRUIT health research

This is focussed on animal and human studies, and on the use of nutrigenomics. There is a hierarchy of evidence in health and nutrition, i.e. different kinds of scientific work may be ranked into a hierarchy of evidence and by setting standards for quality of experiments and trials. The order is human dietary trials > observational studies >

Figure 1: Effects of apple and apple products on cholesterol levels in rats



animal studies > in-vitro models. A large rat study has been conducted in which male F344 rats were randomised into groups with varying feeding schedules: (i) 'western type diet' (WTD) (25% fat, 60% corn starch), (ii) WTD + 10g whole apple/d, (iii) WTD + apple pectin (7g/d), WTD + apple juice (mL/d), (v) WTD + apple pomace (10g/d), (vi) control. Urine and faeces samples were tested and the rats were sacrificed at periods from 11 to 23 months age when blood samples were also taken. Apple pomace has a dietary fibre content >50% and also has antioxidant properties. Apples and their fractions lowered total serum cholesterol in rats (Fig. 1) with whole apples and apple pomace the most effective (Fig. 1). Cloudy and clear apple juice and apple pectin also reduced cholesterol but the effect was not statistically significant. Apple pomace and whole apples also reduced low density lipoprotein cholesterol (LDL) but pectin had a minimal effect (Fig. 2).

Figure 2: Effects of apple & apple products on LDL cholesterol levels in rats

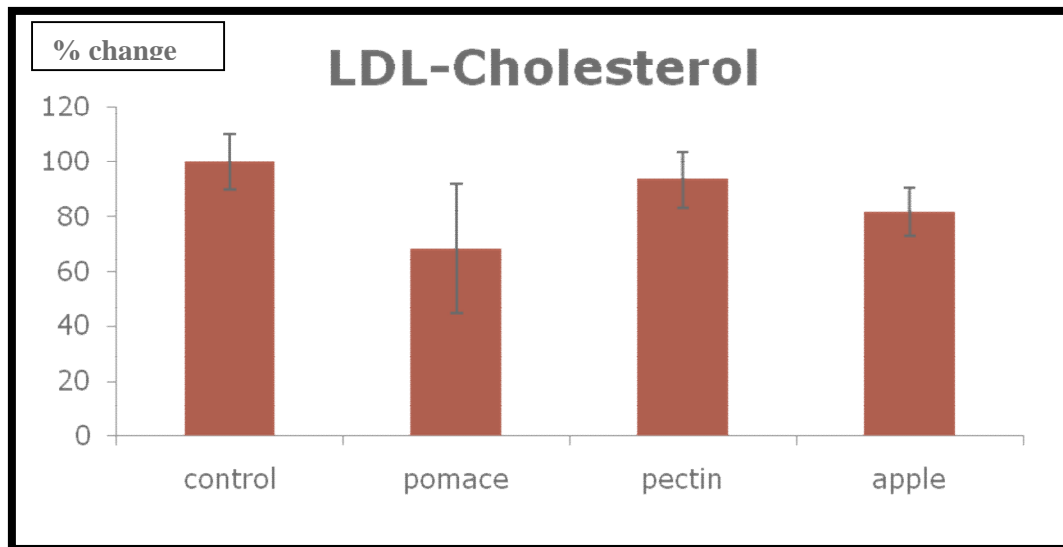
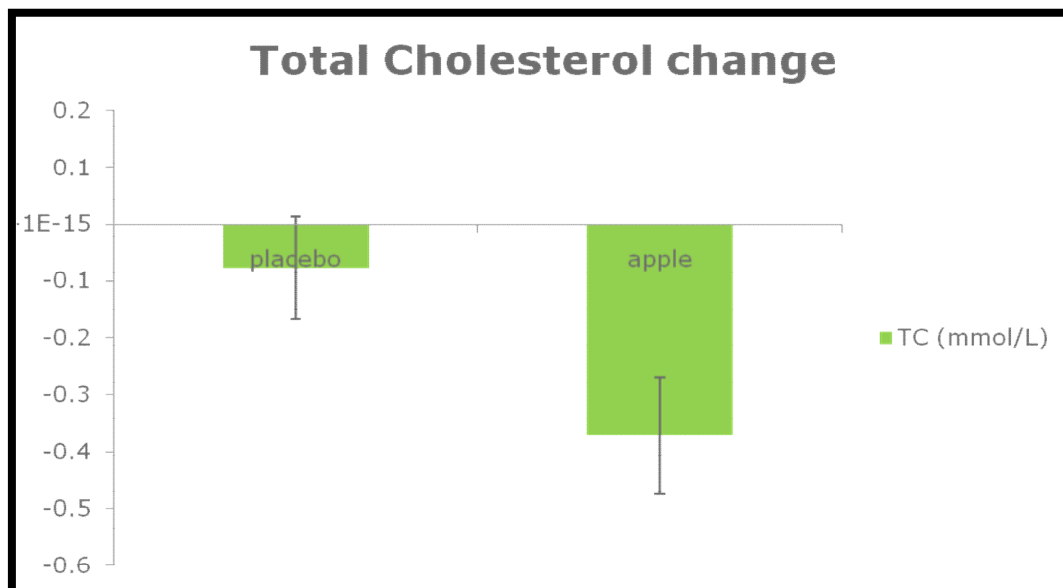


Figure 3: Effect of apples on serum cholesterol levels in humans



Following the trial with rats, a major human intervention study was conducted. As expected, apples (circa 400g/d) reduced cholesterol levels in humans and the mechanism for this was also pursued, again using rats. Apples and apple pomace

Figure 4: Effect of apples on bile acid excretion in rats after 4w feeding

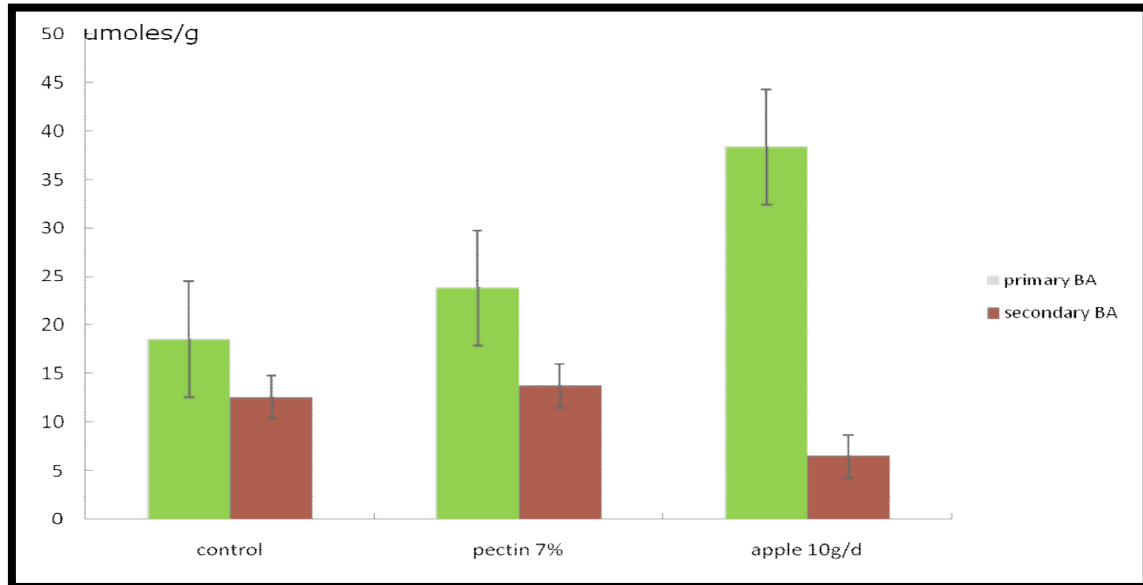
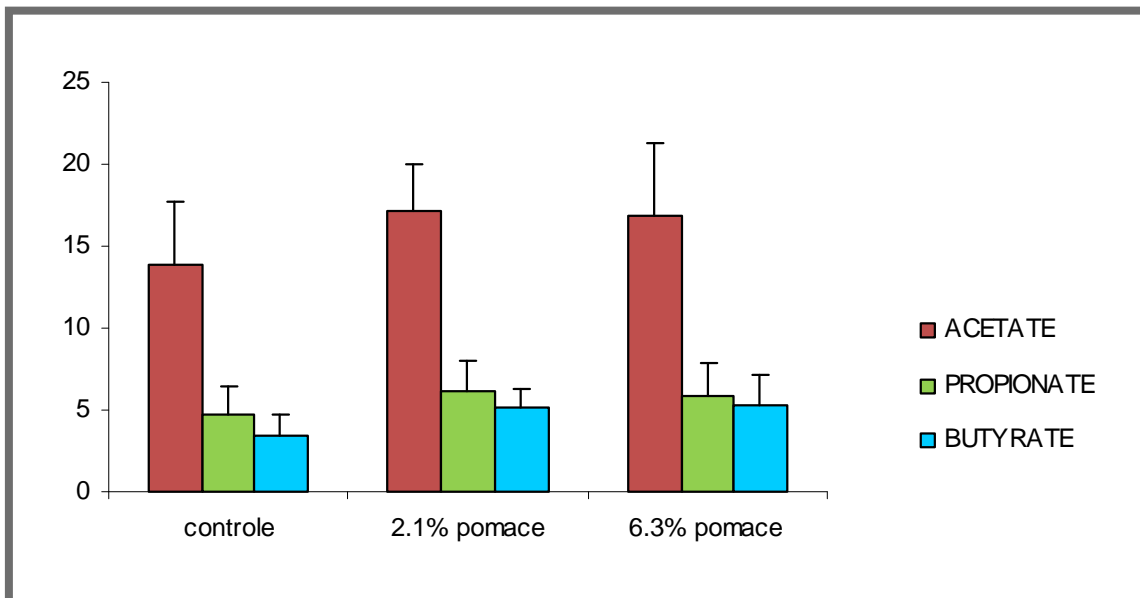


Figure 5: Effect of pomace in the rat diet on short chain fatty acid (SCFA) concentration and caecum weight



increased primary bile acid production; the bile acids are excreted which in-turn causes cholesterol to break down to give more bile acids to replenish the pool. In this way total cholesterol is lowered (Fig. 4). Inclusion of apple pomace in the rat diet increased the production of short chain fatty acids (SCFAs) and these are

hypothesised to reduce hepatic cholesterol synthesis. Both butyrate and propionate were found in increased concentrations in the caecum in the rat study.

The conclusions from the work above and that of other partners in ISAFRUIT give partial answers to the following four questions:

What is state of the art within fruit and health research? Fruit prevents CVD and may affect some cancers, but very few –if any- of the true causative factors making fruit healthy are known. Solids-non-sugar including cell wall components seem important, and soluble factors in juices are not giving the same effects as whole fruit.

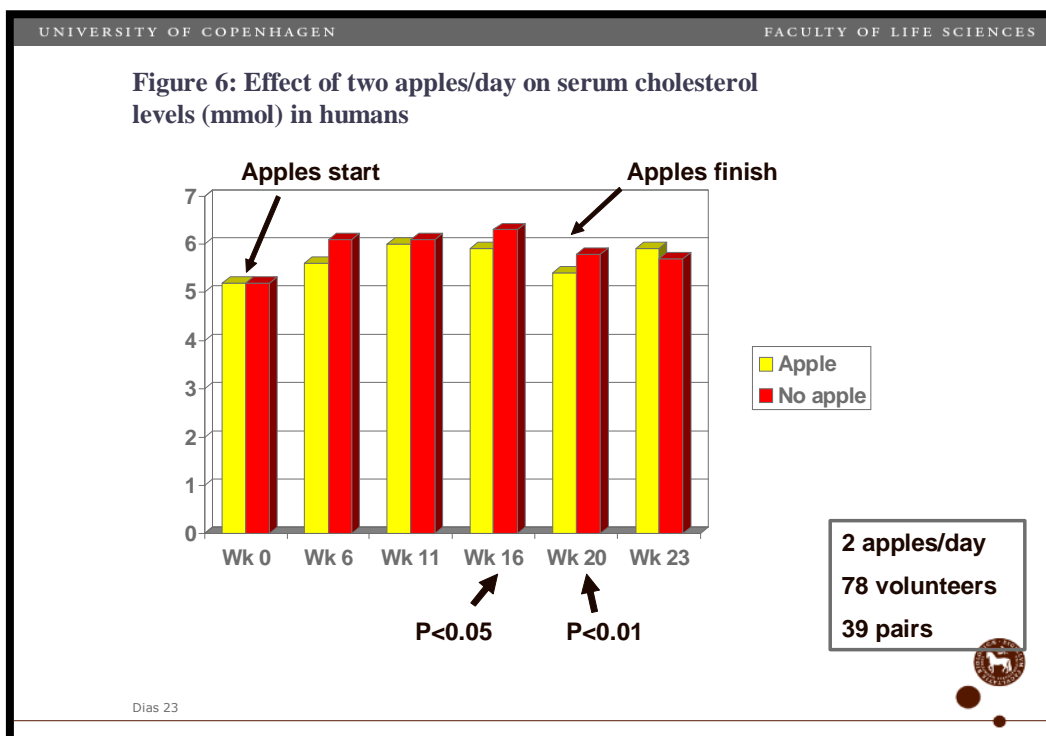
What are the hypotheses? The gut-liver axis is affected by fruit in multiple ways. Explorative techniques rather than deduction is the way ahead to achieve new hypotheses

Which results have been achieved? A range of mechanisms have been identified as related to fruit and health; several of them are true risk markers of disease

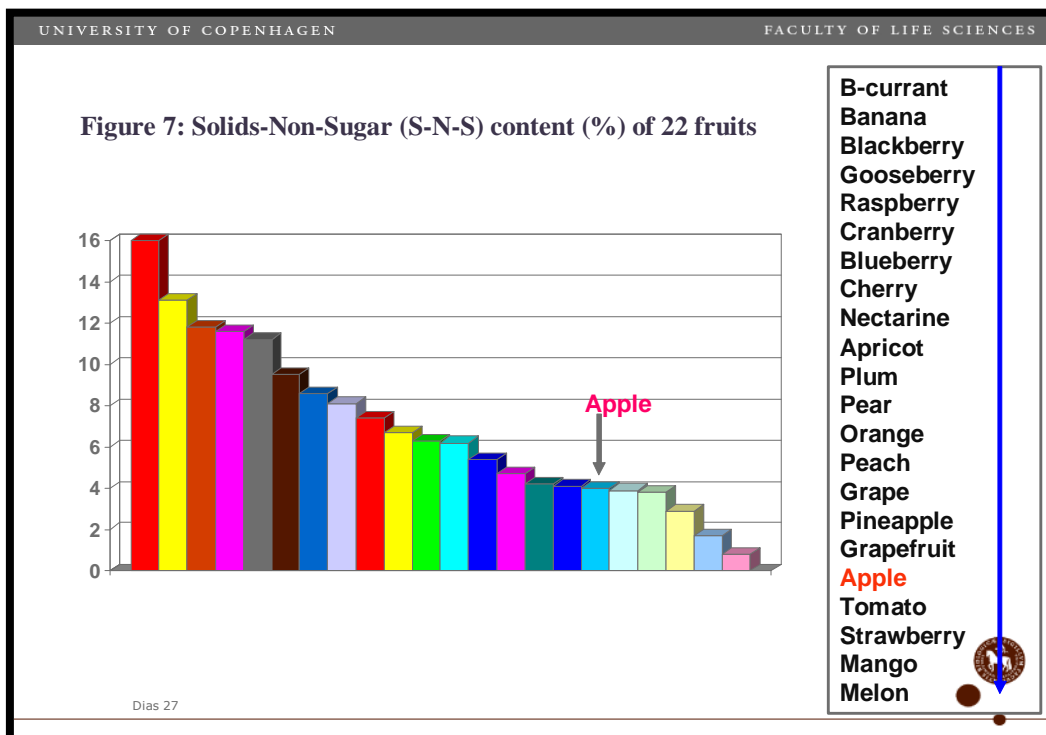
What does future work focus on? Bioinformatics based on ISAFRUIT results from animal and human studies

Links between the ISAFRUIT research and earlier results

Research published in 1979 (Gormley et al.) indicated that two apples a day reduced serum cholesterol in humans and raised the high density lipoprotein (HDL) fraction (Fig. 6). It was postulated at the time that this was due to binding of bile acids by apple cell wall material, followed by excretion, thereby causing cholesterol to break down to replenish the bile acid pool. The findings above from ISAFRUIT support this

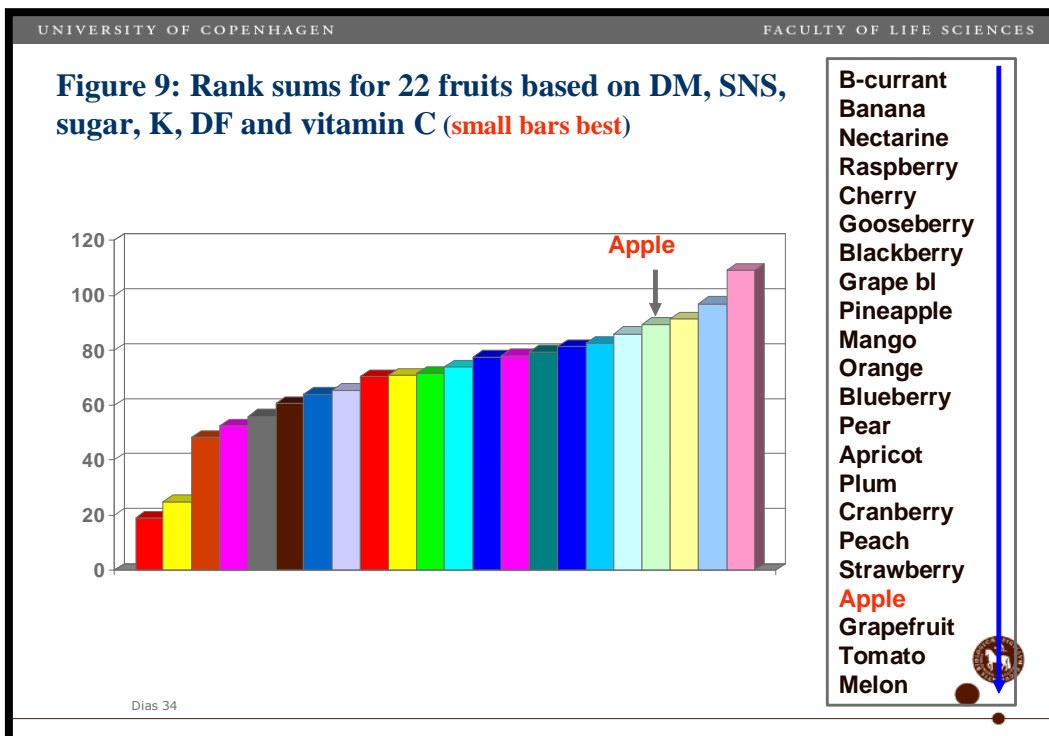
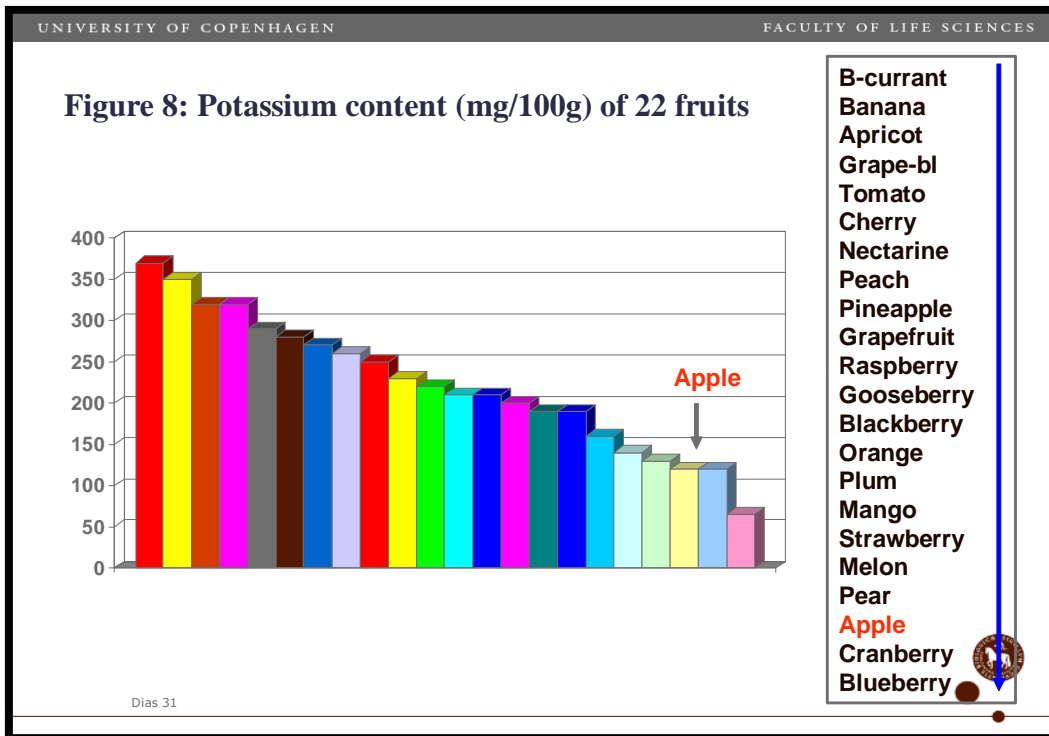


theory. The 1979 study used 78 volunteers; paired (39 pairs) based on similar cholesterol levels; one person in each pair consumed 2 apples/d for 20 weeks; the other person did not. The edible part of 2 apples weighs circa 300g = 47g of dry matter = 12g of solids-non-sugar (SNS). This contains cell wall material, vitamins, minerals, antioxidants, protein and some fat ----the so-called potential bioactive parts of the fruit, and is fairly similar in composition to apple pomace. In another study, consumption of 15g/day of alcohol-insoluble-solids (AIS) from apples as a slurry also



lowered cholesterol in diabetic subjects (Mayne et al., 1982). AIS are fairly similar to pectin and to SNS. In view of this the approximate SNS content of 22 different fruits was compiled from standard food composition tables (Fig. 7). Blackcurrants contain circa 16% SNS which is four times more than apples. It is postulated, therefore, that blackcurrants (eaten on an equal weight basis to apples) should potentially be four times more 'potent' than apples in reducing cholesterol. Other fruits with SNS >10% are banana, blackberry, gooseberry, and raspberry (Table 7). On this basis SNS from a whole range of fruit may offer potential for cholesterol reduction in humans when consumed as a powdered preparation in slurry form. Alternatively, the same potential benefit should be attainable by consuming the whole fruit equivalent.

Fruit is a good source of potassium which is beneficial for blood pressure reduction and hence protective for cardiovascular health. Black currants, bananas, apricots and black grapes have potassium contents in excess of 300mg/100g making them very good sources (Fig. 8). The potassium can be obtained by eating the whole fruit or the SNS fractions. The 22 fruit types have been ranked on the basis of their content of dry matter (DM), solids-non-sugar (SNS), sugar, dietary fibre, potassium and vitamin C. On this basis the eight highest ranked fruits were black currants, bananas, nectarines, raspberries, cherries, gooseberries, blackberries and black grapes (Fig. 9).



Overall conclusions

*Fruits are beneficial for cardiovascular health and may also play a role in the prevention or advancement of other diseases.

*Consume up to 5 portions of F&V per day as part of a balanced diet.

- *Whole fruit are generally more beneficial than puree which in turn is more beneficial than juice; i.e. packaged nutrients (in cell tissue) are usually best.
- *If possible, obtain nutrients from foods that contain them.
- *Fruit preparations (e.g. solids-non-sugar) may also offer potential for cholesterol reduction and other health benefits.

Acknowledgements

We thank a number of ISAFRUIT colleagues, especially those in laboratories in Denmark and Ireland, for their contributions to this research, and also the European Commission for part-funding the research programme: [Thematic Priority 5:-Food Quality and Safety of the 6th Framework Programme of RTD (Contract No. FP6-FOOD 016279 - ISAFRUIT)].

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Fruit for health: National and international policies

Mike Gibney, UCD Institute of Food and Health, University College Dublin, Dublin 4
e-mail: mike.gibney@ucd.ie

Introduction

Food and nutrition policies exist in most developed countries to a greater or lesser extent. They have a number of basic functions including: (i) ensuring the availability of a healthy, nutritious and safe food supply; (ii) being proactive in promoting healthy eating, e.g. making the healthy options the easy options; (iii) informing consumers of recent outcomes from health professionals regarding diet and healthy eating; (iv) driving education programmes aimed at all segments of the population, but especially the young and the elderly, about the benefits of a good diet and on the easiest way to obtain same; (v) creating awareness that the most nutritious foods are often the cheapest. For example, mackerel are among the most nutritious of fish and yet they are the cheapest fish on the supermarket ice counter; porridge oats are an excellent cereal and are one of the cheapest on a per-serving basis. The focus in the current presentation is narrower and looks at national and international policies in relation to fruit consumption and the likely consequences for health.

Policies, goals and objectives

A policy is typically described as a deliberate plan of action to guide decisions and achieve a rational outcome, and embraces goals versus objectives. Goals are broad, brief statements of intent that provide focus or vision for planning. Goals are warm and fuzzy. They are non specific, non-measurable, and usually cannot be attained. The UN Millenium Goals are illustrated in Fig. 1 and range from eradicating extreme hunger and poverty at one extreme, to global partnership for development at the other. Objectives must be S.M.A.R.T., i.e. specific, measurable, achievable, realistic and time-bound.

World Health Organisation (WHO) survey

The WHO has conducted a survey on fruit and vegetable intakes which also includes definitions and recommended intakes (Keller, 2003). Objectives of the survey included (i) similarities and differences in definitions of fruit and vegetables around the world; (ii) qualitative information on general fruit and vegetable consumption; (iii) highlighting existing dietary recommendations; (iv) highlighting existing and promoting new/activities relating to fruit and vegetables.

Some definitions of fruit are as follows:

Cambodia: Fruits are foods from a plant source. They are usually consumed after a meal or as snacks. Fruits are usually consumed raw but some are cooked. Most fruits taste sweet but some are sour or bitter.

Lebanon: Fruits are a rich source of vitamins, minerals, salts and dietary fibre. They are sweet, refreshing and are usually consumed raw after a meal.

Estonia: Fruits and berries are consumed fresh, frozen, dried and also as purees, juices, and as cooked or canned. The definition does not include jams with high sugar content.

Figure 1: UN Millennium Development goals (MDG 2015)



Figure 2:

Example recommendations

- Ghana: v: >1 portion; f: 2-4 portions
- Panama: v: 2 portions; f: 2 portions
- France, Luxembourg, Germany, Island, Italy, Poland, Norway, New Zealand, Cook Islands, Western Samoa: > 5 portions
- Thailand: 500 g
- China: v: 400-500g; f: 100-200g



World Health Organization



? ? UCD Institute of Food and Health

Five-a-day concept

The 5-a-day concept is most successful food-based dietary guideline ever developed. Most people believe it is based on strong epidemiology from the US National Institute of Health (NIH). However, it was developed as a marketing tool by the California fruit and vegetable industry, was adopted by the NIH, but is still co-funded by its founders. Some daily intake recommendations for fruit (f) and vegetables (v) portions from different countries are presented in Fig. 2. Ireland has no specific National Nutrition Policy (NNP) relating to fruit and vegetables, and their promotion in the diet is based on advice from the Department of Health, The Irish Heart Foundation, Bord Bia (especially the 'Food Dudes' school programme), other organisations with a health mission, dietitians, the media, retailers and producers. 'Five-a-day' is commonly advocated but is not policy driven.

National Adult Nutrition Survey (NANS)

Much of the information on the Irish diet is based on the NANS (2010). Key features include: (i) 1,500 adult participants; (ii) 1,250 gave blood and urine samples; (iii) physical activity measured via Actigraph and IPAQ; (iv) anthropometric measurements (weight, height, % fat, weight/height); (v) attitudinal, lifestyle, medical, socio-economic aspects; (vi) genetic data (gene sequence and expression); (vii) metabolomic profiles; (viii) proteomic profiles; (ix) food intake; (x) nutrient intake.

Strategy for implementing food-based dietary guidelines

This embraces (i) increasing fruit and vegetable consumption of consumers, and (ii) increasing the percentage of consumers who eat an adequate portion of fruit and vegetables each day. Targets should be set and four rules prevail in this regard:

Rule 1: Avoid the tyranny of numbers

Rule 2: Set Interim Attainable Dietary Guidelines (IADG)

Rule 3: All IADGs must be S.M.A.R.T.

Rule 4: Use focus group analysis

The UCD Institute of Food and Health (UCD-IFH) approach is based on nutrition and nutrigenomics and the use of cluster analysis. Tests were conducted on 160 human subjects (Fig. 3) and three distinct clusters were identified:

Cluster 1 was characterised by a higher energy contribution from wholemeal bread, whole-milk, fish, desserts and confectionary and a lower contribution from low energy beverages (Table 1).

Cluster 2 had a higher energy contribution from foods such as savoury snacks, low fat milk, yogurts, fruit, poultry and sauces and a lower contribution from high energy beverages (Table 1).

Cluster 3 contained higher contributions of white bread, sugars and preserves, butter and spreads, red meat, red meat dishes, meat products and alcohol and lower contribution from vegetables (Table 1).

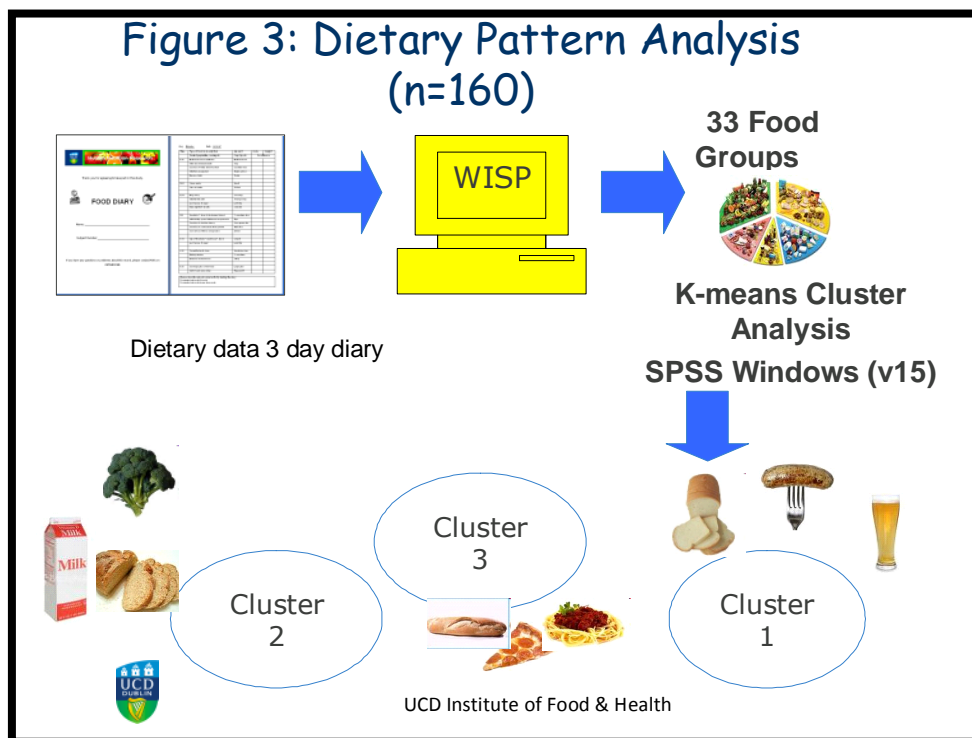


Table 1: Energy and food intake data

	Cluster 1	Cluster 2	Cluster 3	P value
	(n=38)	(n=37)	(n=50)	
Characteristics				
Energy (MJ)	9.7	9.0	10.3	NS
% energy				
Protein	15.1	17.0	15.5	0.01
Carbohydrate	49.0	48.3	45.6	0.05
Fat	36.2	34.3	35.4	NS
Saturated	14.2	11.8	13.9	0.01
Alcohol	2.2	3.1	5.9	0.00
Starch (g)	148	120	161	0.01
Fibre (g)	17.4	17.9	14.0	0.00
Carotene (µg)	4463	3887	2983	0.04
Vitamin C (mg)	144	207	120	0.04



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Nuclear Magnetic Resonance (NMR) spectra of urine samples from the 160 participants enabled pattern recognition, i.e. clustering of people together on the basis of urine signatures. This indicated a distinction between clusters 1 and 3. In the future

it is envisaged that these type of data will be used to develop biomarkers of different dietary patterns.

Environmental aspects

Kamphuis et al. (2006) conducted a systematic review of environmental determinants of fruit and vegetable consumption among adults. The aim of the review was to summarise the existing empirical evidence pertaining to environmental influences on fruit and vegetable (FV) consumption. Findings showed there was a great diversity in the environmental factors studied, but that the number of replicated studies for each determinant was limited. Most evidence was found for household income, as people with lower household incomes consistently had a lower FV consumption. Married people had higher intakes than those who were single, whereas having children showed mixed results. Good local availability (e.g. access to one's own vegetable garden, having low food insecurity) seemed to exert a positive influence on intake. Regarding the development of interventions, improved opportunities for sufficient FV consumption among low-income households are likely to lead to improved intakes. For all other environmental factors, more replicated studies are required to examine their influence on FV intake.

Promoting fruit and vegetables

Knai et al. (2005) reported on 15 campaigns aimed at getting children to eat more fruit and vegetables. Ten of these had a positive effect and increased intake by 0.3-1.0 servings per day. The EGEA Congress on '*Social and Health Benefits of Balanced Diets: the role of fruit and vegetables*' held in Brussels in May 2010 devoted a session on *Policy in Action* with reference to the European and other School Fruit and Vegetable Schemes. Some snippets on the findings (a-d) were as follows (EGEA, 2010):

(a) *French school fruit scheme*: Outcomes re children's knowledge, satisfaction and practices, and also teachers' difficulties in managing the scheme were not always as expected. For example, (i) children don't like kiwi fruit early in the morning as the flavour was not compatible with that of toothpaste; (ii) children don't know how to classify processed fruits/fruit-containing products vis-à-vis what they learned about seasonality; (iii) fruit served during class breaks replace cakes and other sweet items; however, when the children return home they don't change their eating habits.

(b) *Norwegian school fruit programme*: As of the school year 2007-2008 an official free school fruit programme (without parental payment) is in place in all secondary elementary (grades 8-10) and in all combined elementary and secondary schools (grades 1-10). The programme is now supported by legislation making it a legal requirement for municipalities to provide school fruit for their pupils. However, parents have to pay for fruit in elementary schools (grades 1-7).

(c) *Slovenia school fruit scheme*: The school meal programme is providing primary school children with up to four meals a day which include fruit in accordance with recognised guidelines. Free school fruit is being used as a tool for increasing popularity and availability of fruit and vegetables for (low consuming) children in schools.

(d) *USA fresh fruit and vegetable programme*: This is administered by the USDA and each state's child Nutrition Division receives a yearly funding allocation based on student population. Interested elementary schools apply to the state for funding. They receive \$50-75 per student per year to provide a fresh fruit and vegetable snack daily to all their students. The US Congress has provided 3 million for a national evaluation of the scheme and results are expected shortly.

The Irish *Food Dudes* school programme was introduced (i) to change children's behaviour regarding consumption of fruit and vegetables and (ii) to bring about long-term increases in consumption of fruit & vegetables. The programme is being rolled out free-of-charge nationally on an ongoing basis and to date has reached 1600 primary schools. It is highly successful in increasing fruit and vegetable consumption in all classes and schools and there is excellent buy-in from teachers and parents. See http://www.fooddudes.ie/html/parents_what.html

Conclusions

1. Evidence for the benefits of fruit and vegetables in the diet on human health is largely epidemiological. The strongest clinical evidence for a positive health impact is in the area of cardiovascular disease.
2. The 5-a-day concept while not scientifically based provides a useful target for consumers to aim at in relation to their fruit and vegetable intake. This equates to 400-600g/day depending on what constitutes a portion size. Current evidence suggests that most Irish consumers fall well short of this target.
3. There is no national food and nutrition policy in Ireland. However, recommendations for an increased intake of fruit and vegetables are made by health professionals from a plethora of organisations/institutions/agencies.
4. School fruit schemes (with parental support) are a good way forward to increase consumption as they (i) provide daily fruit to the children and make them more aware of the need to replace more calorific items (e.g. sweets, soft drinks) with fruit; (ii) carry-forward to the home and to parents thereby promoting more consumption there also.
5. The media and supermarkets have a major role in promoting increased fruit and vegetable intake; the former by carrying well balanced articles/discussions on the topic; the latter via a wide selection of high quality produce, in-store promotion, and attractive pricing.

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Fruit for Health: Probiotic apple slices

Christian Rößle, Teagasc Food Research Ashtown (TFRA), Dublin 15
e-mail: christian.roessle@teagasc.ie

Introduction

Fresh-cut fruit products are showing an increase in sales in most developed countries. They are convenient and have gained consumer acceptance. There is increasing demand for foods enriched with physiologically active components and development of health promoting foods is one of the key drivers for the food industry. Probiotic bacteria are defined as *live microbial feed supplements which beneficially affect the host animal by improving its intestinal microbial balance*. Regular consumption can confer a number of health benefits such as: reduction of cholesterol, control of gastrointestinal infections; improvement of lactose tolerance; improvement in inflammatory bowel disease; inhibition of some cancers; anti-diabetic properties; anti-diarrhoeal effects and immune system stimulation. Probiotic dairy foods are a well established and are recognised by most consumers as healthy products. However, many people are allergic or intolerant to dairy products and an alternative option is probiotic fruit. The **objective** was, therefore, to apply a probiotic microorganism to fresh-cut apple wedges thereby producing a functional food product, i.e. the inherent functionality of apple wedges plus added functionality of probiotic bacteria.

Procedures and tests

Braeburn was the apple cultivar and the probiotic strain was *Lactobacillus rhamnosus*. Natureseal AS1 was used as a browning inhibitor. The probiotic solution/suspension was prepared from lyophilized cultures grown in MRS broth. Cells were then washed with citric acid-sodium: citrate buffer (pH 3.8) and were re-suspended in citric acid: sodium citrate buffer [pH 3.8; 1:10 (w/v)]. Sample preparation and testing are shown in Figs 1 and 2 respectively.

Results

The complete results of these tests have been published and only an abridged version is reported here (Rößle et al., 2009). Circa $\log 7$ cfu/g is required for a probiotic effect and this number prevailed in the apple wedges for at least 10 days during storage at 2-4°C in both washed and unwashed samples. The washing utilised a buffer solution and was performed to study bacterial adhesion to the slices. The level of adhesion was excellent and was confirmed by Cryo-SEM (surface) and by confocal scanning laser microscopy. There was no difference in browning index between control and probiotic-treated wedges and overall values increased from 23.3 to 25.8 during storage at 2-4°C over a 10d period. The control wedges were firmer than the probiotic-treated on days 0, 2, 4, 6, and 10 and the respective values were 33 versus 29N (day 0) and 36 versus 31N (day 10). Soluble solids content of the two sample sets were not different with the mean circa 12%. Both paired comparison and scoring taste panels were conducted on the samples. The former showed a 13/12 ratio (25 tasters) for control versus probiotic apple wedges and the latter mean scores of 4.25 (control) and 4.20 (probiotic sample) on a 6-cm scale with end-points of 0 (unacceptable) and 6 (very acceptable). This indicated no difference between the samples and also a good level of sensory acceptability.

Figure 1: SAMPLE PREPARATION

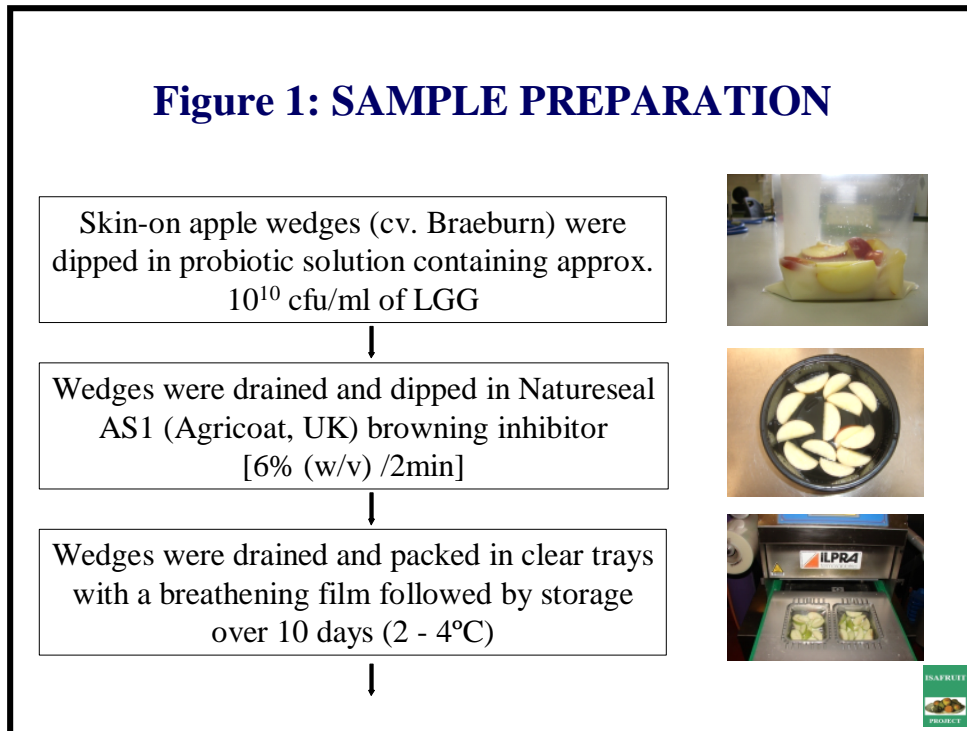


Figure 2: SAMPLE ANALYSIS

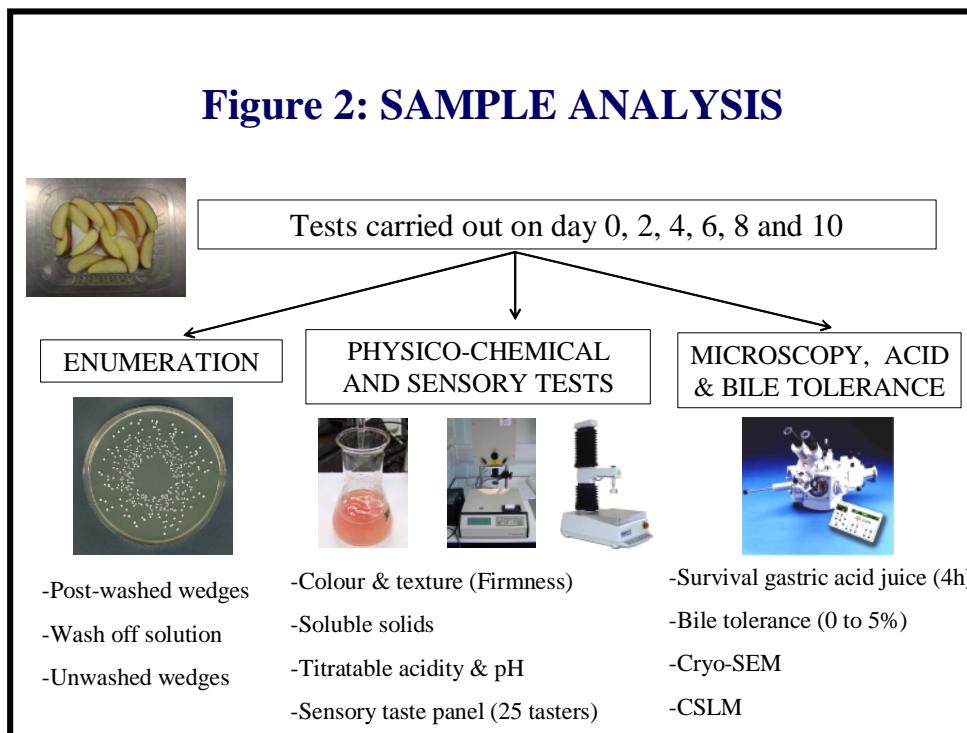
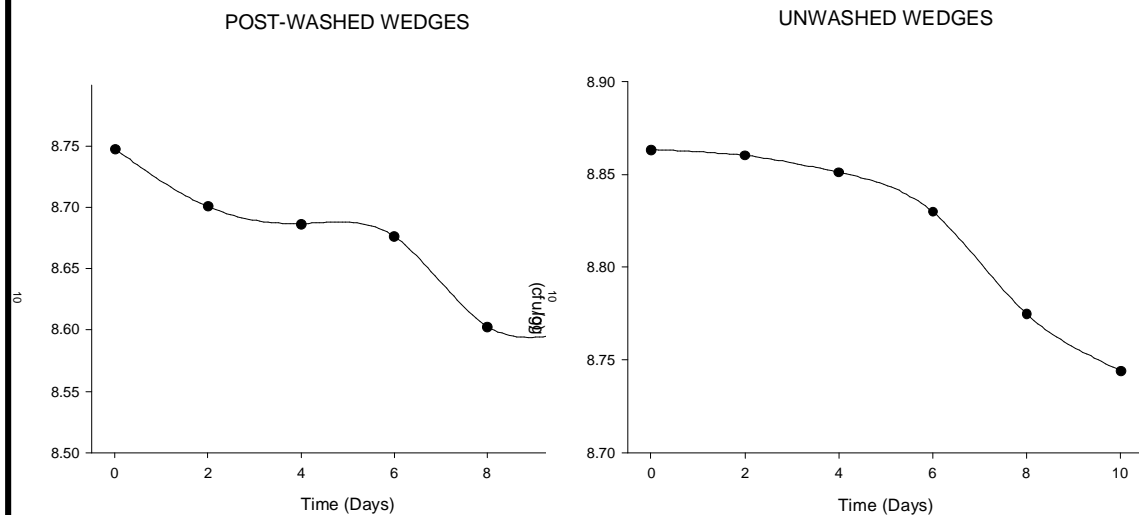


Figure 3: Survival of *L. rham.* on washed and unwashed apple wedges



Enumeration (log scale) of *L. rhamnosus* GG after incubation on Rogosa agar for 72-96 h of post-washed apple wedges and wash off solution in log₁₀ cfu/g over 10 days storage at 2–4 °C

Conclusions

1. Physicochemical and sensory evaluation indicated acceptable quality in apple wedges. There were sufficient numbers of *L. rhamnosus* adsorbed on the surface for a probiotic effect
2. The situation concerning a health claim is unclear. *L. rhamnosus* is a proven probiotic bacterium in dairy media. However, efficacy testing may be necessary when a different carrier, i.e. apple wedges, is used.
3. Probiotic apple slices may provide an alternative for persons allergic or intolerant to dairy products
4. In an extension of this work, tests have been completed on adding a prebiotic (oligosaccharide) via a rapid setting alginate to the probiotic apple wedges thereby producing synbiotic apple wedges.

Acknowledgements

Thanks are extended to the European Commission for part-funding this research as a component of the ISAFRUIT project (Contract No. FP6-FOOD 016279; FP6); to Walsh Fellowship Scheme of Teagasc; to my PhD supervisors Dr. Nigel Brunton (TFRA), Prof. Ronan Gormley (UCD-IFH), Prof. Francis Butler (UCD-IFH) ; to Dr. Mark Auty (Teagasc Food Research Moorepark) for the assistance with the

microscopy; to Prof. Paul Ross (Teagasc Food Research Moorepark) for providing the probiotic strain, and to my colleagues at TFRA.

References

Roessle, C., Auty, M.A.E., Brunton, N., Gormley, T. R. and Butler, F. 2009. Evaluation of fresh-cut apple slices enriched with probiotic bacteria. *Innovative Food Science and Emerging Technologies*. In press.

Fruit for Health: New generation fruit product outcomes from ISAFRUIT project partners

Nigel Brunton, Teagasc Food Research Ashtown (TFRA), Dublin 15
nigel.brunton@teagasc.ie

Introduction

A major objective within Pillar 3 of the ISAFRUIT project was to produce new generation fruit products including fruit dessert-type products. Many conventional processed desserts are dairy-based with a small amount of fruit. The goal here was the opposite, i.e. to produce desserts containing large amounts of fruit with small amounts of accompaniment, e.g. a 4:1 ratio. Four types of product are described below: (i) 1st-3rd generation processed apple puree products; (ii) fruit smoothies; (iii) High Pressure (HP) processed apple products; (iv) microwave processed apple products. The research was conducted by teams of post-graduates headed by the following: Nigel Brunton (TFRA, IE), Ronan Gormley (UCD-IFH, IE), Maribel Abadias (IRTA-Lleida, ES), Pierre Picouet (IRTA-Monells, ES), Inmaculada Vinas Almenar (UdL, ES), Paddy Callaghan [Nature's Best Ltd (NBL), IE].

1st–3rd generation apple purees and wedges (TFRA & NBL, IE)

Generation 1: Selecting/optimising cultivars and processes

A number of apple cultivars were obtained from the Polish ISAFRUIT partners and their suitability for the process applications was tested alongside other cultivars including the Irish-grown cultivar Bramley's Seedling; the last mentioned cultivar is well known as an excellent processing cultivar because of its unique blend of acidity and astringency.

Procedure and tests: Details of the methods for processed wedges (W) and purees (P) are given in Fig. 1. The samples were cored, peeled, wedged and soaked in Natureseal AS1 (Agricoat Ltd, UK) browning inhibitor solution [6% (w/w)/2 min]. The samples for processing as **wedges** were par-cooked by microwaving (1-1.75min/700w) and then vacuum packed. Sub-sets of these were *chilled* (2-4°C for 1-10d; test), *freeze-chilled* (blast freeze to -30°C; stored at -20°C for 1-12 weeks; tempered at 4°C overnight; stored for 1-10d at 2-4°C; test), or processed by *sous vide* (Barriquand Steriflow cooker; $F_{90} \leq 10$ min; store 1-30d at 2-4°C; test). The samples for processing as **purees** were stewed (95°C/15min), sieved (1.4mm² sieve size), vacuum packed and subsets were processed by chilling, freeze-chilling or by *sous vide* as described above. Physicochemical (dry matter; soluble solids; titratable acidity; colour; texture; cell integrity) and sensory tests [acceptability on a 6-cm scale with end-points of 0 (unacceptable) and 6 (very acceptable); or paired comparisons using 20-30 tasters] were conducted after various time intervals on the different sample sets.

Results and outcomes: The tests on different cultivars were conducted as wedges and purees and the wedge data are presented here. Alwa, Gloster, Granny and Champion had the highest shear values and Jonagold, Elstar, Cortland and Rajka wedges were softest. Braeburn, Gala and Bramley wedges had intermediate values (Fig. 2).

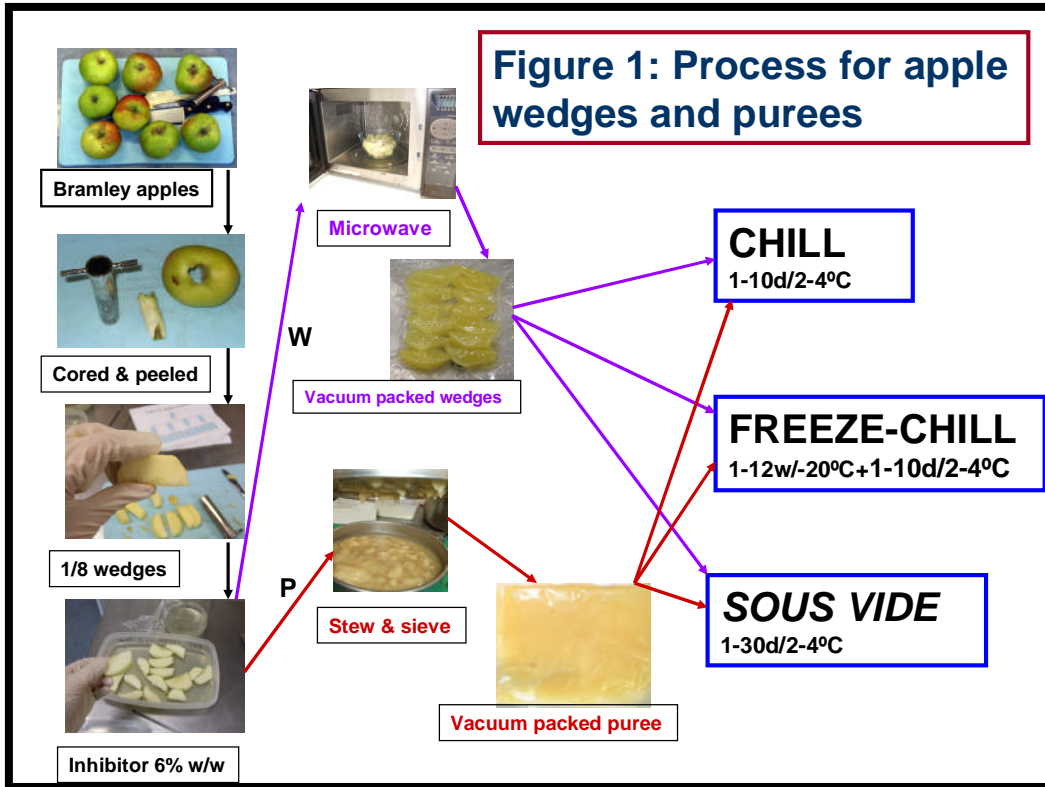
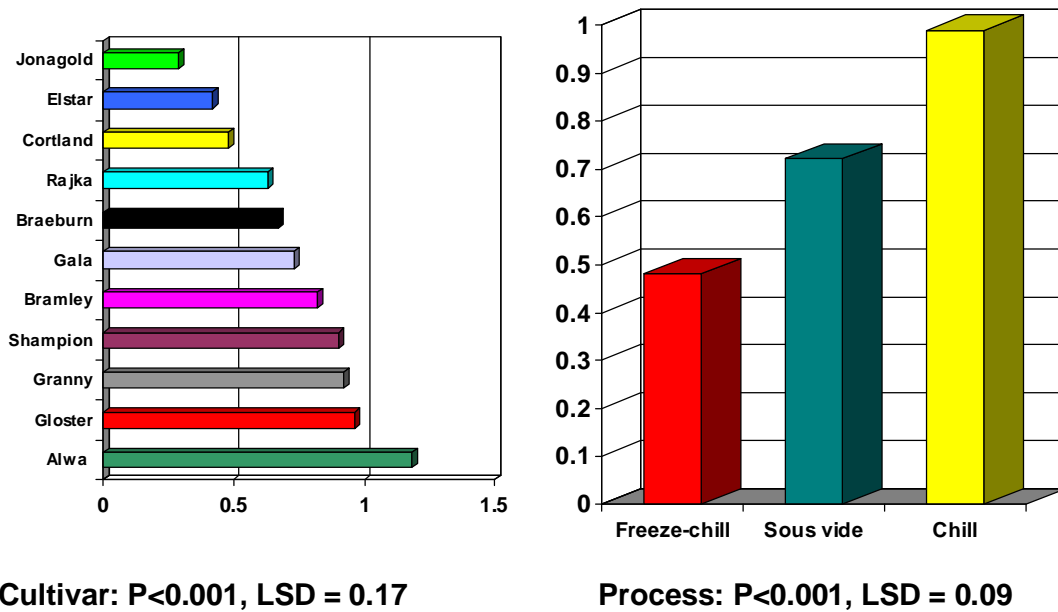
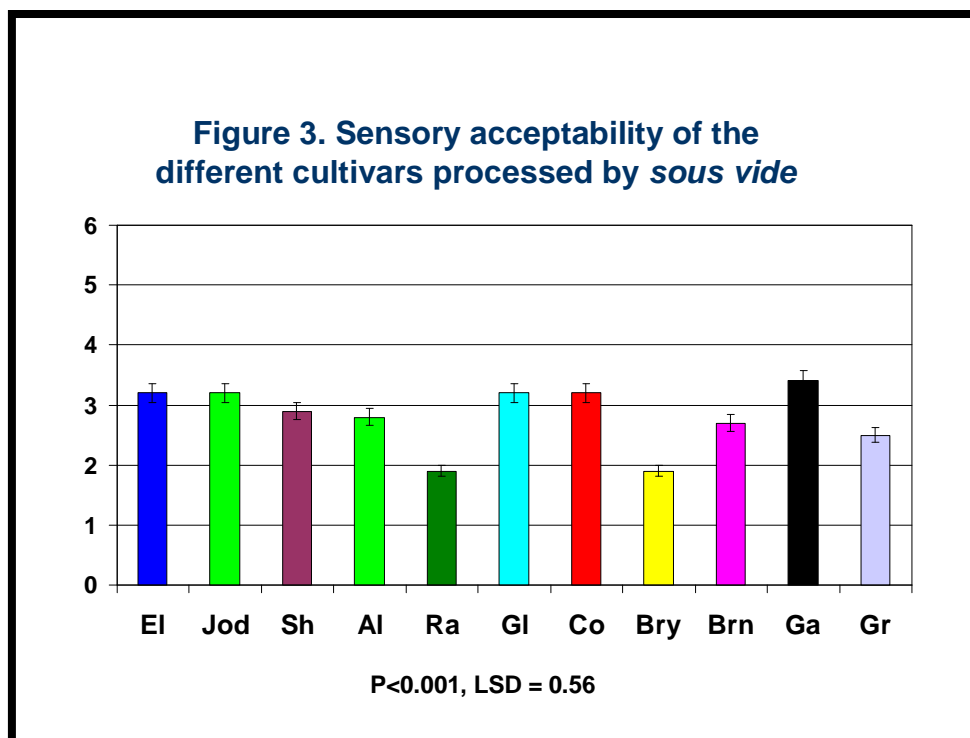


Figure 2: Texture (Kramer shear press) values (kN) for apple cultivars and processes



The wedges processed by chilling were firmest while freeze-chilled sets were softest due, presumably, to the freezing step. *Sous vide* processed wedges had an intermediate texture. Alwa, Cortland and Gala had the best wedge colour [Hunter L/b (white/yellow ratio)] as had sample processed by *sous vide* in comparison with chilled or freeze-chilled samples. Sensory tests indicated that five cultivars (processed by *sous vide*) received sensory scores > 3, i.e. Elstar, Jonagold, Gloster, Cortland and Gala; Rajka and Bramley were the lowest scoring (Fig. 3). When viewing these data



it is important to stress that the samples were served unsweetened which put cultivars like Bramley at a disadvantage relative to the others.

Conclusions from Generation 1 tests: The overall data show that the best performing cultivars were Alwa, Cortland and Gloster, and the lowest Jonagold and Rajka. *Sous vide* performed best of the three processes based on data for shear, colour and sensory acceptability.

Generation 2 products: Purees containing functional ingredients

This trial involved adding nutraceuticals to Bramley puree and processing the samples by chilling, freeze-chilling or *sous vide*. Most ready-desserts are dairy-based and the purpose here was to provide an alternative for those allergic to dairy products, i.e. functional apple puree products.

Procedure and tests: The nutraceuticals were (i) apple pomace (supplied by the Polish ISAFRUIT partners) which is an antioxidant dietary fibre, (ii) an oligosaccharide (Beneo™, Beneo-Orafti, Belgium) which is a prebiotic, dietary fibre and sweetener, and (iii) alcohol-insoluble-solids (AIS) material prepared from apples at AFRC; this is a dietary fibre with cholesterol lowering properties. The flow scheme for the products was as shown in Fig. 1 but going the puree (P) route. The nutraceuticals were added post-stewing to the puree and prior to vacuum packing. The processing and storage

Figure 4: Browning index for processed apple purees with oligosaccharide (Beneo) or alcohol soluble solids

Small bars are best

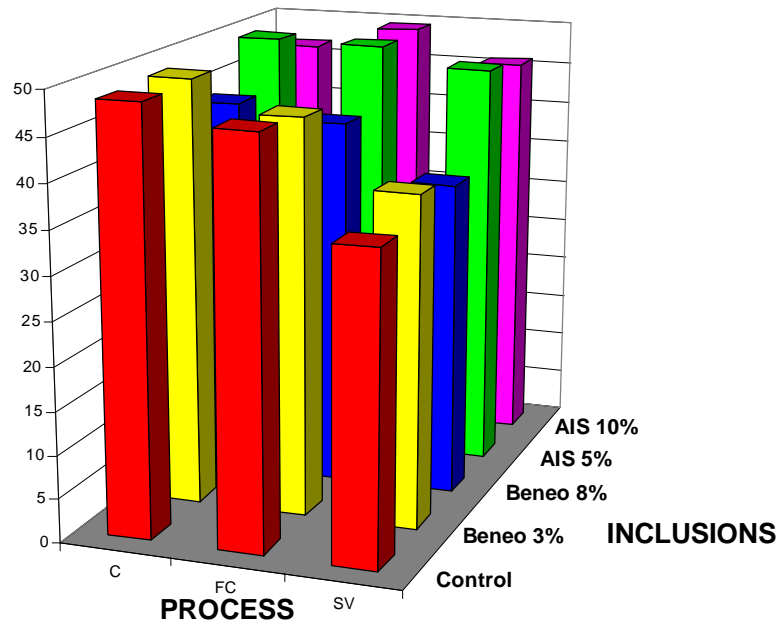
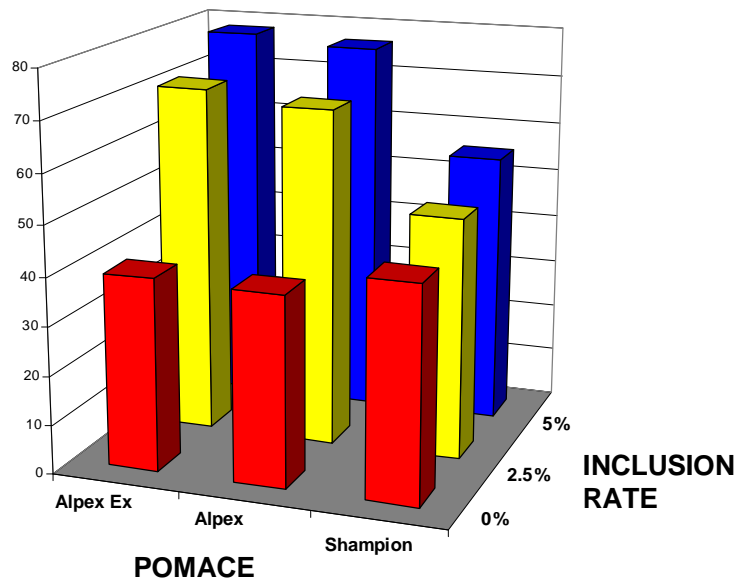


Figure 5: Browning index for processed apple purees with blackcurrant or apple (cv Champion) pomace

Small bars are best



conditions, and the physicochemical and sensory tests, were similar to those used for Generation 1 products except that viscosity/consistency replaced shear testing. Browning index (BI) was calculated from the equation:

$$x = \text{BI} = 100(\chi - 0.31)/0.172$$

where $\chi = a + 1.75L/(5.645L + a - 3.012b)$

Low values for the browning index are best.

Results and outcomes: Maintaining the light colour of the puree is a priority and in this regard the purees with oligosaccharide (Beneo) at 3 and 8% inclusion were best (Figure 4). AIS at 5 and 10% increased browning as did processing by chilling (C) or freeze-chilling (FC), in comparison with *sous vide* (SV) (Fig. 4). This is because Beneo is a white powder whereas the AIS have a brown in hue. Fig. 5 shows the browning index for puree with blackcurrant (Alpex Ex and Alpex) and apple (cv Champion) pomace at different inclusions. As expected, the coloured blackcurrant pomace darkened the purees while Champion pomace had a minimal effect. This apple cultivar is noted for its low browning tendency and its pomace is white in colour. Beneo™ had little effect on colour or texture and its inclusion at 8% increased sensory acceptability. Both pomaces and AIS increased the viscosity of the purees.

Conclusions from Generation 2 tests: Beneo™ at 8% (w/w) in the processed purees is in sufficient quantity to have prebiotic effect in the gut. It also enhanced puree acceptability. Champion pomace can be accommodated in the purees up to 7.5% (w/w). This contributes 3.3% additional dietary fibre to the puree in addition to antioxidants. The purees with these inclusions can be considered as doubly functional, i.e. the functionality of the inclusions plus the inherent functionality of the apple puree.

Generation 3 products: Purees containing functional ingredients and accompaniments

This embraced two trials:

1. Apple purees containing accompaniments (custard or cream or aerosol cream)
2. Apple purees containing an accompaniment (custard) and functional ingredients [pomace or Beneo™ (oligosaccharide)].

Procedure and tests: For **Trial 1** the accompaniments were included before vacuum packing the apple wedges or purees (cultivar Bramley) as per Fig. 1 at a ratio of 4 parts apple to 1 part accompaniment. All samples (purees and wedges) were packed in plastic bags together with *cream* (double strength), *aerosol cream* [Carié (BoyneValley Foods, Drogheda, Ireland), 79% dairy cream (fat content 40%), skimmed milk, sugar (3%)] or *custard* (made from 130g powder in 900ml water to give 1L of custard). The packs were processed by chilling, freeze-chilling or *sous vide* as for Generation 1 products and were subjected to physicochemical and sensory testing. Bramley puree was used in **Trial 2** and processing was by *sous vide*. Custard was the accompaniment (4 parts puree to 1 part custard) and the nutraceuticals were Champion pomace (5% inclusion), or Beneo™ (oligosaccharide) (8% inclusion) or both together. The preparation procedure was as per Fig. 1 [puree (P) route] with the inclusion being made before vacuum packing the desserts.

Results and outcomes:

Trial 1: Appearance: The wedge samples looked better than the purees. Of the accompaniments in-pack, samples with cream looked good but the aerosol cream lost its structure, probably due to the vacuum treatment of the bags. Flavour: All samples, with the exception of aerosol cream, tasted too sour due to the high acidity and astringency of the Bramley apples. The samples with aerosol cream were sweeter as the aerosol cream contained sugar. The flavour of the accompaniments in-pack was good, especially for the samples with aerosol cream which had an attractive caramel note. The tests were done within a couple of days of processing and long term trials are needed to study the flavour of the accompaniments, especially potential rancidity, and also microbiological status over time. Texture (sensory): The *sous vide* samples had the best texture (firmest) and the freeze-chilled ones were too soft. Presumably the over-soft texture of the freeze-chill samples was due to tissue damage during freezing. Texture (objective): Shear values were much higher for the *sous vide* samples due to the gentle cooking procedure. The values for the chilled samples were intermediate suggesting that the microwave cooking treatment may have been too severe. The freeze-chill samples were softest especially for those with custard and cream. Consistency: The apple purees with custard had a low consistency (Brookfield viscometer) which was not affected by freeze-chilling. The chilled samples with cream and aerosol cream had the highest consistencies, but values were lowered by freeze-chilling or *sous vide* processing, especially in the case of samples with aerosol cream. All the samples exhibited shear thinning, i.e. consistency values fell with increasing rates of shear. Conclusions from Trial 1: Ready desserts (one-pack) were produced using Bramley apples with cream, aerosol cream or custard as accompaniments. The sensory properties for the samples with cream or custard were good while the aerosol cream broke down in the samples, presumably due to vacuum packing.

Trial 2: Inclusions of Beneo and pomace raised the soluble solids (SS) content of the purees (Table 1). Pomace inclusion increased titratable acidity (TA) but had a darkening effect on puree colour (Hunter L values); this was paralleled by raised Hunter 'a' (redness) and reduced Hunter 'b' (yellowness) values. The inclusion of pomace greatly increased viscosity (Brookfield rheometer; spindle speed 5 rpm) of the three puree types (Table 1). Single stimulus taste testing was conducted on the samples (10 tasters) with panellists tasting one sample per day, i.e. consumers usually only consume one food portion at a sitting. Panellists marked a 6-cm line with end-points of 0 (unacceptable) and 6 (very acceptable). Apple desserts with Beneo or with both nutraceuticals received acceptability scores equal to or better than the control; the inclusion of pomace on its own reduced acceptability. With peach, Beneo improved sensory acceptability compared to the control, but inclusions of pomace or both nutraceuticals had a negative impact on acceptability. Pomace inclusion on its own reduced acceptability of the plum dessert; however, combining with Beneo gave a good acceptability score (Table 1). Plum desserts had a much lower TA than apple or peach. There was excellent oligosaccharide retention (i.e. minimal hydrolysis) in all three desserts; this was attributed to the mild *sous vide* process. Retention levels were 94% (apple puree), and circa 100% (plum and peach purees). Conclusions from Trial 2: The fruit puree products are described as fruit⁺⁺ products to take account of the inherent functionality of the fruit and the added functionality of the nutraceuticals. These products are potential new entrants to the ready-dessert range currently available in retail outlets.

Table 1: Physicochemical and sensory properties of fruit puree desserts containing nutraceuticals and custard

Dessert	SS (%)	TA (meq/100g)	Lightness (L)	Viscosity Pa.s	Sensory (0-6)
Apple					
Control	9.8	7.9	66.1	27	4.3
Beneo (B)	16.3	8.3	63.1	16	4.3
Pomace (P)	12.8	10.4	52.5	96	2.4
B + P	19.8	10.9	50.9	33	4.6
Peach					
Control	10.0	9.0	60.8	10	3.4
Beneo (B)	15.5	8.5	56.5	13	4.8
Pomace (P)	12.5	11.6	51.9	26	2.3
B + P	16.0	13.6	51.5	20	2.6
Plum					
Control	10.5	4.2	52.9	5	2.4
Beneo (B)	16.0	4.1	52.4	4	3.0
Pomace (P)	13.5	6.7	48.2	12	3.5
B + P	18.3	6.0	45.2	10	4.4

Fruit smoothies (TFRA, IE and NBL, IE)

Introduction

Fruit smoothies are finding increasing shelf space on retail outlet shelves as consumers seek convenient healthy product options. Trials were conducted at IRTA (Monells, ES) on the effect of thermal and high hydrostatic pressure processing (HPP) on the quality attributes of fruit smoothies.

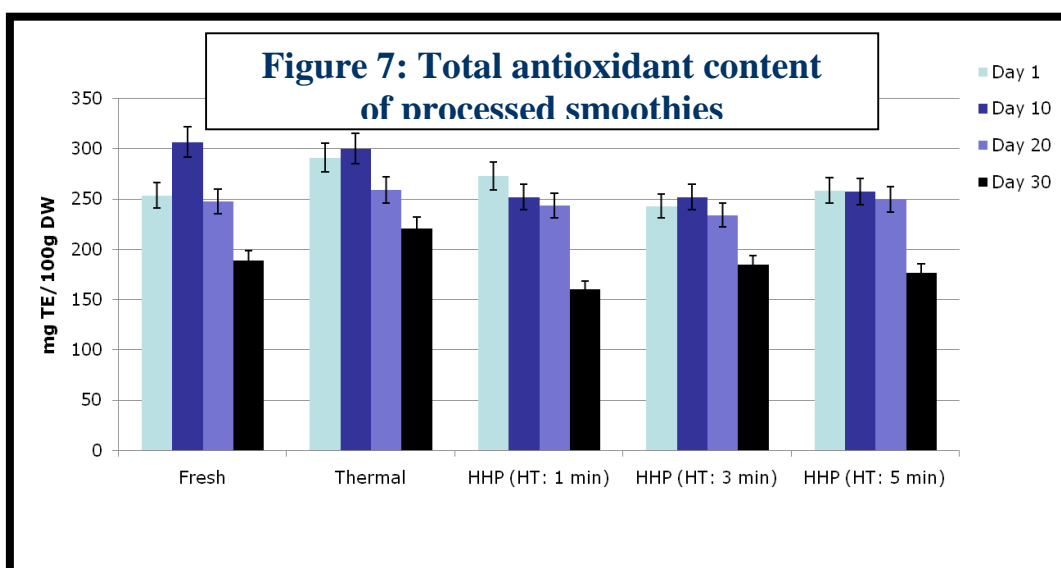
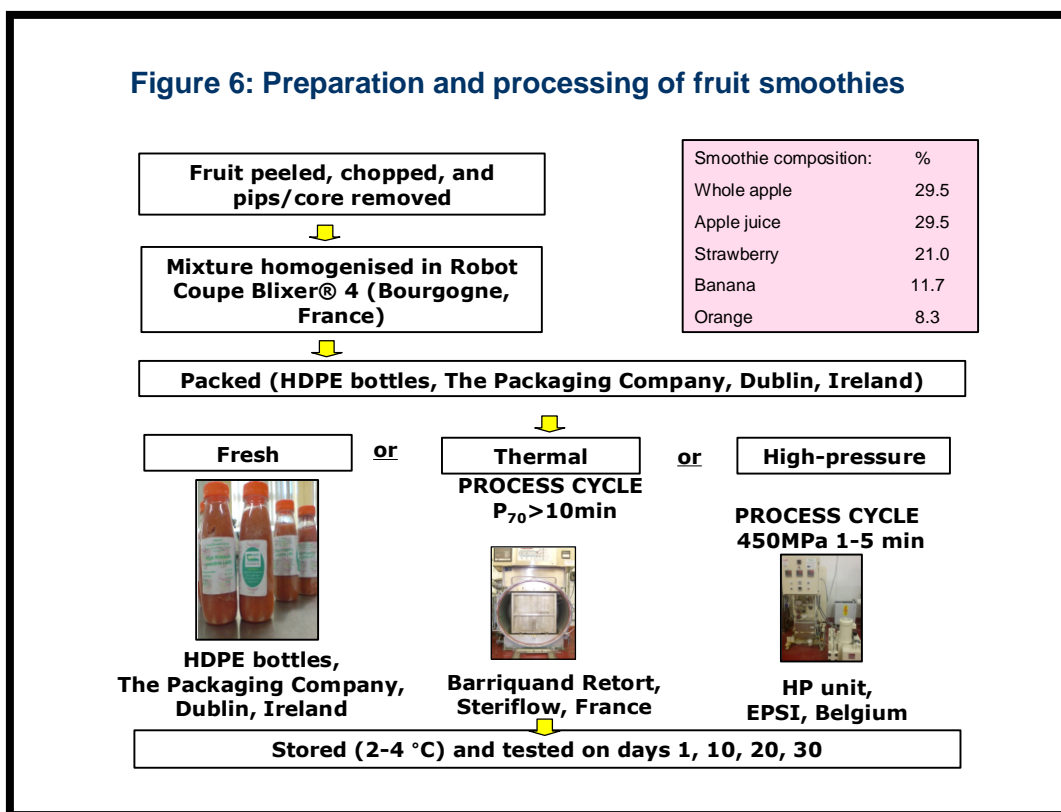
Procedures and tests

The procedures and processing conditions for the smoothies are presented in Fig. 6. Physicochemical and sensory testing was conducted on days 1, 10, 20 and 30 during storage at 2-4°C. There was particular focus on the fate of antioxidants and related compounds during the storage period.

Results

In terms of smoothie *colour*, high pressure processing (HPP) reduced Hunter L values (lightness) compared to the control smoothies and thermal treatments. The L values remained relatively constant, from a practical point of view, during 30 days storage at 2-4°C. In contrast to L values, the HPP treatments led to increased 'a' values, i.e. more redness, compared to the control and thermal treatments while there was a fall off in 'a' values over the first 10 days at 2-4°C. Hunter 'b' (yellowness) values were unaffected by the process but there was a gradual fall-off in 'b' values during the 30-day storage period. The changes in Hunter Lab values were viewed collectively via the colour difference (ΔE) values. Most of the colour changes took place as a result of processing, especially by HP, and changes thereafter during storage at 2-4°C were smaller. Process and storage had a minimal effect on smoothie *pH* but there was a rise in *titratable acidity* (TA) during storage at 2-4°C especially for the HP treatments. This may be due to changes in the buffering capacity of the smoothie system during

Figure 6: Preparation and processing of fruit smoothies



storage; this, in turn, could be caused by some precipitation of soluble solids (SS) during storage at 2-4°C. This theory is supported by the SS data which showed a fall-off during storage of the smoothies. Viscosity (Anton Parr rheometer) of the smoothies was not influenced by processing but values fell for the processed smoothies during storage at 2-4°C. This may have been due to precipitation of some of the materials responsible for product viscosity. The effect was largest for HP-5 min. All smoothies exhibited shear thinning. Sensory scores for the smoothies were well above the mid-point (3) of the sensory scale indicating a good level of acceptability. The exceptions were the thermal treatment on day 20 (2.98) and the freshly made control on day 30 (1.84). The latter effect may be due to bitterness (orange oil?) in the citrus component of the smoothie. Total viable counts (TVCs): TVC values for the processed smoothies were $< \log_{10} 3$ cfu/g throughout the storage

period and there was complete absence of pathogens. Both process ($P < 0.001$; LSD 14.45) and time (days; $P < 0.001$. LSD 10.07) influenced the total antioxidant content of the smoothies (Fig 7). Retention was best for the thermal treatment and there was a decline in values with time and especially between days 20 and 30. Bar charts for total phenols and hesperidin showed a similar pattern to that in Fig. 7.

Conclusions

High pressure processing is a suitable technology for processing smoothies and the product had good physicochemical, sensory and microbiological properties/scores during storage for 30 days at 2-4°C. On balance, holding times between 1 and 3 min were the best HPP treatments and are recommended for future trials at pilot scale.

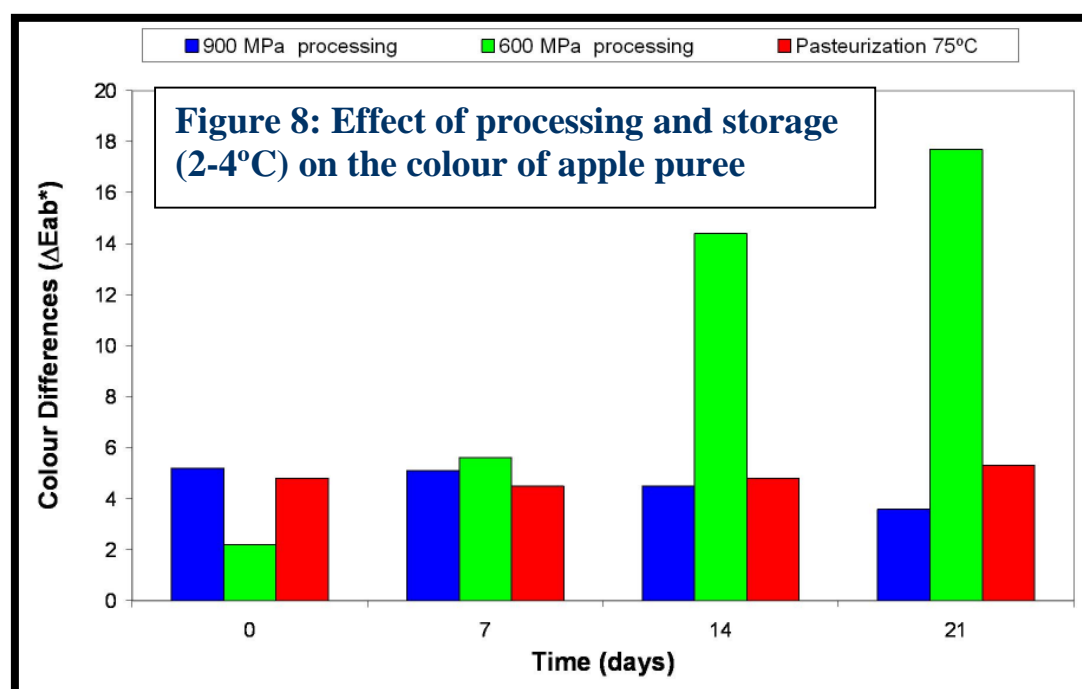
High pressure (HPP) and microwave processing (MWP) of fruit products

Introduction

These trials were conducted by three research groups in partnership, i.e. IRTA (Monells), IRTA (Lleida) and the University of Leida (UDL). The objective was to investigate the suitability of HPP or MWP for processing fruit products with emphasis on product quality, vitamin C retention, and microbiological status.

Effect of HPP on the colour of apple puree

The effect of HPP and thermal processing on the colour of Granny Smith puree was tested by comparing three treatments: (i) HPP at 900 MPa; (ii) HPP 600 MPa; and (iii) thermal processing at 75°C. The samples were stored in the dark at 2-4°C and sets were tested on days 0, 7, 14 and 21. Tristimulus colour measurements (L,a,b) were made and the colour difference values (ΔE) were computed.



The results indicated little difference between the treatments in terms of colour change during processing up to day 7. However, by days 14 and 21 of chilled storage

the puree from the 600 MPa process had changed colour significantly from that of the original fresh unprocessed puree (Fig. 8).

Effect of HPP on (i) survival of indigenous microbiota on apple and peach segments stored at 5-10°C; (ii) effect of HPP on product quality

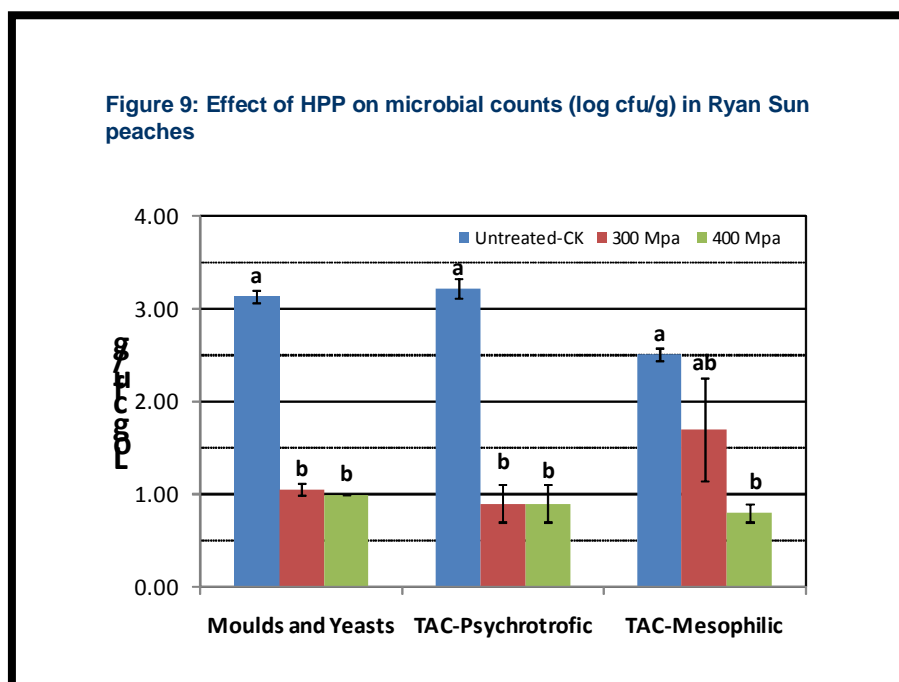
(i) Introduction

The efficacy of HPP for reducing the indigenous microorganism content fruit segments was evaluated using the cultivars Fuji (apple) and Ryan Sun (peach). Counts of mesophilic (30°C, TAM) and psychrotrophic (6.5°C, TAP) microorganisms, and of moulds and yeasts (M & Y) were made during storage of the products at 5 and 10°C.



Table 2: Effect of HPP on microbial counts in Fuji apple segments

	Initial (cfu/g)	HPP; 350Mpa; 3 min (cfu/g)	Reduction (log)
TAM	7.1×10^2	1.2×10^1	1.1
TAP	3.4×10^2	8.3×10^0	1.4
M&Y	1.8×10^2	5.3×10^1	0.6



(i) Results and outcomes for HPP of apple segments and peaches

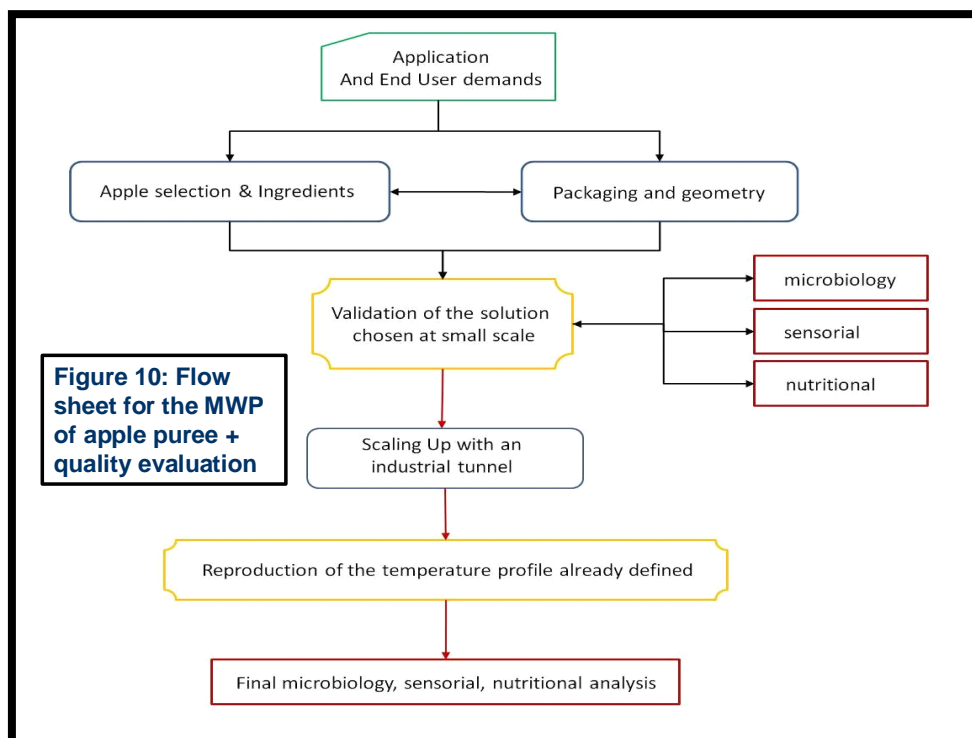
Growth of the three groups of microorganisms occurred at 5 and 10°C in untreated and treated apple samples. Reduction of the bacterial numbers following HPP treatment was between 0.6-1.4 log units in Fuji apples (Table 2). The microbiological quality of fresh-cut apples treated with HPP was acceptable over 21 days at 5°C. In the case of peaches, microbial reduction was between 1 and 2 log units, with no significant differences between pressures. HPP peach pieces showed good microbiological stability during 28 days at 2-4°C, with counts <100 cfu/g (Figure 9).

(ii) Introduction

Microwave processing (MWP) may offer considerable benefit at industrial level for the preservation of fruit purees and nectars. The objective of the current trials was to produce apple purees by MW heating with a shelf life of 15 days at 4-5°C and with emphasis on colour, flavour and vitamin C retention.

(ii) Results and outcomes for MWP of apple purees

A flow sheet for the process and testing schedule is given in Fig. 10. The parameters used in industrial scale testing were: temperature 72.6°C; heating rate: 1.5°C/s; maximum power 18kW; belt speed 200cm/min; time in cavity 55 s; packaging trays 125 x 100 mm.



The main findings were: (i) use of MWP gives good microbiological stability during storage for 15 days at 5°C; (ii) an anti-browning agent is needed to maintain puree colour; (iii) ascorbic acid stability significantly higher in MWP apple puree than in conventionally processed (48.5 vs 36.3% respectively); (iv) processing costs were circa 0.12 cent/kg of fruit product.

Acknowledgements

Thanks are extended to the EU FP6 Programme for part-funding this research under the ISAFRUIT project [Contract No. 06279 (Food)] and to the many personnel (work-packages 3.1 and 3.2) who conducted the trials.

Discussion and Consensus Statement on Fruit for Health

The efficacy of fruit for lowering human cholesterol was noted as was the mechanism which has been largely clarified based on the work in the University of Copenhagen. The potential of solids-non-sugar for lowering cholesterol was discussed especially for blackcurrants, gooseberries and blackberries which have a much higher content than apples, and it could be argued that they could be 3-4 times more effective than apples on an equal weight basis. This could be a rewarding area for future research.

The basis for the 5-a-day recommendation is largely artificial and is not based on the outcome of clinical trials. Its commercial origins were noted; nevertheless it is a target to be aimed at for increasing fruit and vegetable intake. It was agreed that promotion of fruit schemes in schools is a good way to increase consumption as it embraces both children and parents. The jury remains out on antioxidants as it has yet to be proven that they have a high degree of efficacy in combating disease, and especially inflammatory diseases. Obtaining antioxidants from fruit that contain them may be more beneficial than consuming antioxidant concentrates.

Probiotic apple slices were considered an innovative new option especially for persons allergic to dairy products, e.g. probiotic yogurts. However, calling them probiotic apple slices may pose a problem as mention of the word 'probiotic' constitutes a health claim. The bacterium used in the apple wedges is a well proven probiotic in dairy based systems. However, the use of a new carrier, i.e. apple wedges, may mean that efficacy testing may need to be done for this application; the cost of such tests is largely prohibitive. Clarification was sought via the European Food Safety Authority (EFSA) but no opinion was ventured. The greater strictness of EFSA than the USA authorities re efficacy testing of functional foods is putting European producers of functional foods at a commercial disadvantage relative to their USA counterparts.

The range of new functional apple dessert processed products (fruit purees) developed as part of the EU ISAFRUIT project was considered a welcome alternative. They contrast with current ready-desserts which are largely dairy product with a small amount of fruit. The ISAFRUIT products are the opposite with 4 parts fruit to 1 part accompaniment (custard; cream; soya cream). Functional ingredients in the form of oligosaccharides (prebiotic; dietary fibre; sweetener) or apple pomace (an antioxidant dietary fibre) were included. However, health claim issues (as mentioned for probiotic products) may militate against commercial production of the products.

CONSENSUS STATEMENT: Fruit is considered beneficial for health and clinical evidence for its benefits is best for its positive effect on cardiovascular health; other possible beneficial effects are mostly based on epidemiological evidence. The role of antioxidants in preventing disease needs to be further researched before definitive recommendations can be made. The 5-a-day campaign is not based on sound clinical evidence; however, it remains a useful target to aim for in increasing fruit and vegetable consumption in populations. The need for efficacy testing for functional food claims, and the strictness of EFSA relative to the USA authorities, may militate against the commercial development of new functional fruit products.

SECTION 2: FRUIT AND THE CONSUMER

Choosing the right apple and peach variety for each consumer

Joan Bonany, Research and Technology for Food and Agriculture (IRTA), Girona, Spain

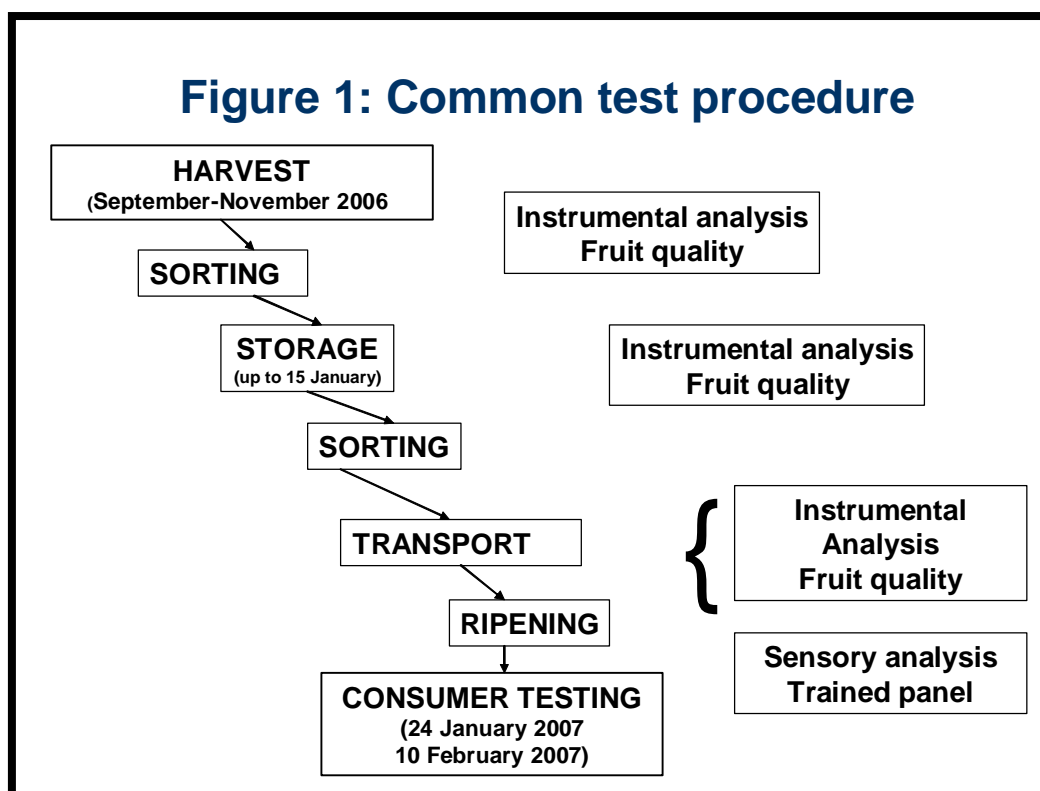
e--mail: joan.bonany@irta.cat

Introduction

There are a number of potential barriers for consumers when buying fruit including sub-standard quality, food safety issues, lack of convenience and availability, cost and lack of knowledge about the fruit being purchased. There are four A's when buying apples: (i) acceptability; (ii) availability/accessibility; (iii) affordable; (iv) addressing multiple motives. Benefits perceived by consumers include fruit taste, safety, health-promoting image, and convenience in that order of importance. The objectives of the current study (part of the ISAFRUIT project) was to (i) evaluate how new better quality fruit cultivars can help to increase fruit consumption; (ii) to develop consumer preference maps.

Procedure

The objectives were achieved by carrying out tests across Europe, i.e. in France, Netherlands, Germany, Poland, Switzerland, Italy and Spain. There was a common methodology and approximately 5000 consumers took part (Fig. 1). There were 11 apple cultivars and 12 peach/nectarine cultivars; two peach/nectarine cultivars were tested at two stages of maturity.



The standard apple cultivars were Golden Delicious, Jonagold and Fuji and the less well known were Pink Lady® (Cripps Pink), Ariane cov, Wellant, Junami® (Milwa), Kanzi® (Nicoter), Rubens® (Civni), GoldChief® and Ligol. The 17 test locations for the consumer panels were Warsaw, Hamburg, Haarlem, Utrecht, Lausanne, Paris, Bordeaux, Castelsarr., Bologna, Rome, Girona, Barcelona, Valencia, Zaragoza, San Sebastian, and Madrid.

Results and outcomes - apples

The grouping from the consumer preference mapping indicates two mega groups, i.e. A and B (Fig. 2). The former likes sweet balanced varieties and the latter acidic varieties. Both groups can be subdivided further and the final outcome is the apple varieties segregated into three groups based on consumer preference (Fig 2).

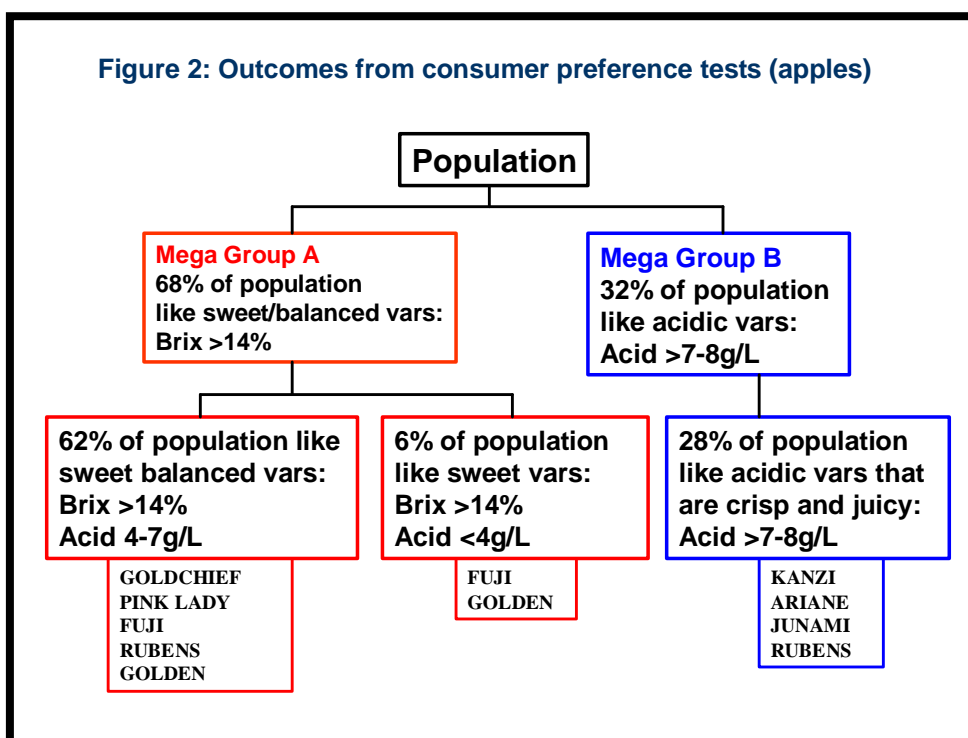


Table 1: Breakdown (%) of Mega Groups A & B (Fig. 1) on a country basis (apples)

Country	Mega Group A	Mega Group B
France	69	31
Germany	42	58
Italy	72	28
Netherlands	69	31
Poland	76	24
Spain	74	26
Switzerland	63	37
Total	68	32

A breakdown of the two Mega Groups on a country basis is presented in Table 1. Germany and, to a lesser extent Switzerland, showed a different preference behaviour

in that there were less persons in the Mega Group A than in B, i.e. there was a greater consumer preference for acidic apple varieties. The visual perception of the apple varieties was in the order Kanzi (1st) > Ligol > GoldChief > Junami > Pink Lady > Ariane > Golden Delicious > Rubens > Wellant > Fuji > Jonagold (11th).

Results and outcomes – peaches and nectarines

The different varieties tested are given in Fig. 3 as are harvest dates and flesh colour classifications. As for apples, the grouping from the consumer preference mapping indicates two mega groups, i.e. A and B (Fig. 4). The former likes sweet varieties and the latter acidic varieties. Both groups can be subdivided further, i.e. Groups C2 and C3 like sweet, firm aromatic varieties while Groups C1 and C4 prefer sweet low acid varieties. Groups 5 and 6 like aromatic acidic varieties (Fig. 4). Breakdown on a country basis (Table 2) indicates that Polish consumers show a major preference for sweet varieties while Germany has the highest percentage of consumers liking acidic varieties, i.e. 25% of consumer test group. Nectaross had the best visual appearance but was not acceptable for the population segment preferring sweet nectarines (87%). Nectareine had the best flavour acceptance and was one of the varieties best accepted by 72% of the population; it has average visual acceptance.

Figure 3: Peach and Nectarine varieties in the consumer tests

#	VARIETY	ORIGEN	HARVEST DATE	GROUP
1	ROYAL LEE® ZAIPELA	CTIFL	30/7/2007	Peach yellow flesh (sub acid)
2	ELEGANT LADY® MERDAME	IRTA	31/7/2007	Peach yellow flesh (equilibrated)
3	ALIROSADA	ISF-Forli	26/7/2007	Peach white flesh acid (aromatic)
4	OPALE® MONCAV	CTIFL	26/7/2007	Peach white flesh
5	NECTAPOM® NECTAREINE	IRTA	24/7/2007	Nectarine yellow flesh (subacid)
6	NECTAROSS cov	IRTA	24/7/2007	Nectarine yellow flesh (acid)
7	NECTAPOM 29® NECTAREINE (m)	IRTA	30/7/2007	Nectarine yellow flesh (subacid)
8	NECTAROSS cov (m)	IRTA	30/07/2007	Nectarine yellow flesh (acid)
9	AUGUST QUEEN® CALDESI 2010	ISF-Forli	26/7/2007	Nectarine white flesh (acid)
10	NECTASWEET 28® NECTAPERLE	IRTA	31/7/2007	Nectarine white flesh (subacid)
11	SWEET CAP® MAILLARFLAT	IRTA	27/7/2007	*Paraguay* (white flesh)
12	MOUNTAIN GOLD	IRTA	27/7/2007	Clingstone non-melting flesh

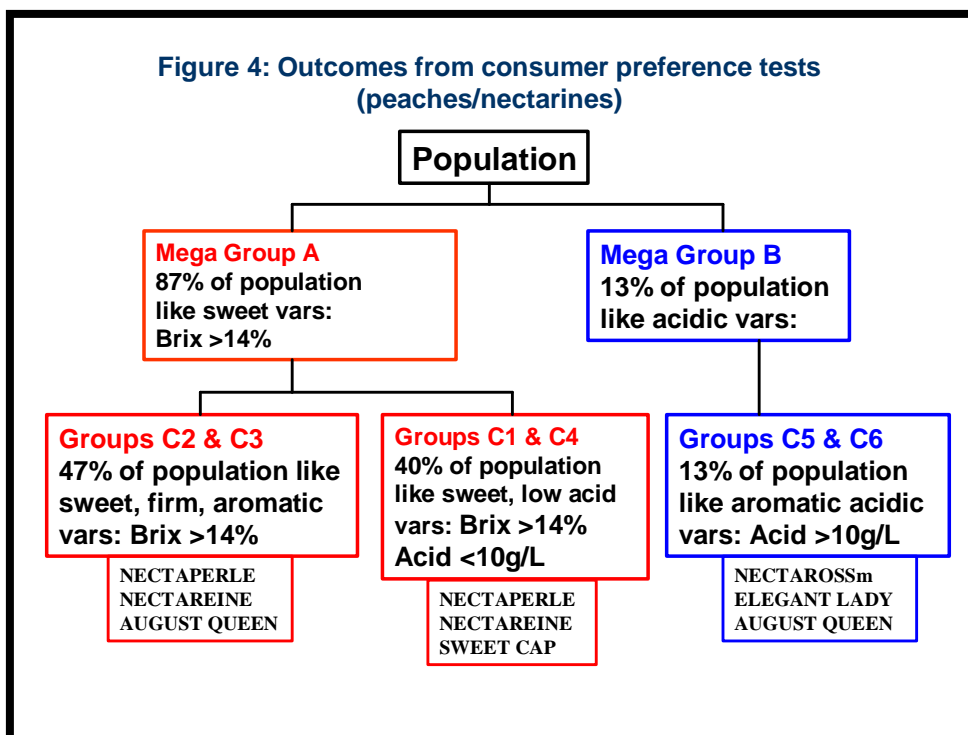


Table 2: Breakdown (%) of Mega Groups A & B (Fig. 3) on a country basis (peaches/nectarines)

Country	Mega Group A (sweet vars)	Mega Group B (acidic vars)
Poland	96	4
France	90	10
Italy	86	14
Spain	83	17
Germany	75	25
Total	87	13

Conclusions

Two major population segments were found for both products (apples, peaches/nectarines). Mega Group A represents 68-87% of the population liking sweet varieties and Mega Group B (28-13% of the population) liking low acid varieties. Age or gender of the consumers did not influence the outcome. However, German consumers had a greater liking for acidic fruit than consumers in the other countries. There was no relationship between visual appearance and flavour acceptability. These outcomes suggest that fruit consumption can be increased by ensuring that consumers have access to the cultivar types they prefer (i.e. sweet or acidic). This requires good communication between all in the fruit production, distribution and retailing chains. Feedback to breeders is particularly important to ensure specific breeding for specific population segments and also releasing new varieties each year. More research on consumer preferences is needed, especially in countries not covered in the present study. There is also a need for fruit preference information for specific segments of the population, e.g. children.

Consumer trends in fruit (Ireland): 2010

Lorcan Bourke, Bord Bia, Dublin
e-mail: lorcan.bourke@bordbia.ie

Introduction

The role of Bord Bia, the Irish Food Board, is to act as a link between Irish Food, Drink & Horticulture suppliers and existing and potential customers throughout the world. The objective is to develop markets for Irish suppliers and to bring the taste of Irish food to more tables world-wide. With its headquarters in Dublin, Bord Bia has a network of International offices in Amsterdam, Dusseldorf, Frankfurt, London, Madrid, Milan, Moscow, New York, Paris and Shanghai.

Bord Bia personnel have surveyed the current behaviour and attitudes of Irish consumers towards fruit purchase and consumption in a survey conducted in 2010. The results have been compared with outcomes from a previous survey conducted in 2006. The surveys benchmark fruit consumption at particular points in time and provide a platform for launching campaigns or initiatives to increase fruit consumption.

Procedures for 2010 survey

The survey covered consumption of many different food types but only outcomes on fruit and fruit related foods are presented here. The survey procedure was as follows:

- A 20-minute questionnaire was administered in a face-to-face manner, in the respondent's own home by fully trained interviewers
- The research was conducted among a representative sample of adults aged 18+ in the Republic of Ireland
- Quotas were set on gender, age and social class to ensure a representative sample
- The full sample size completed was **796** Irish consumers aged 18 and over
- Fieldwork was completed in March 2010
- The methodology used was the same as was used in the original 2006 study, allowing for comparisons to be made between the two

Outcomes: frequency of fruit consumption

Fresh fruit was consumed by 98% of respondees, fruit juices by 91% and yogurt with fruit (86%). All figures for 2010 are higher than in 2006. The increase was largest for

Table 1: Percentage of 796 consumers eating fruit or fruit products in 2010 vs 2006

Product	2010	2006
Fresh fruit	98	96
Fresh-cut chilled fruit	57	54
Fruit juice	91	88
Yogurt with fruit	86	82
Canned fruit	74	71
Frozen fruit	46	44
Fruit smoothies	72	58

smoothies and this was probably due to increased availability in 2010. These data do not give quantification as the question asked was ‘did you eat fruit on any occasion in 2010’. Frequency data are presented in Table 2 and reasons for eating more fruit in Table 3. Less than half the participants ate fruit daily and only a quarter of them fruit juice daily (Table 2). Ten ‘rational categories’ are presented in Table 3 and the first two categories had the highest frequencies (Table 3). Rational data for eating more fruit. The reasons for a change in rational between 2006 and 2010 were for health and taste reasons (Table 3). There was also a large negative change for ‘easy to prepare and cook’ which is, perhaps, a reflection that more people want to eat fresh fruit rather than cooked. Twenty four people gave rationalised reasons for not eating fruit, i.e. ‘never really think about it in my diet’ (7 mentions), ‘don’t like the taste’ (7 mentions), ‘prefer other foods’ (4 mentions), ‘family don’t like the taste’ (3 mentions) and ‘expensive/poor value’ (3 mentions).

Table 2: Frequency (%) of consumption of fruit (2010)

Product	Daily	4-5 times/week	Weekly
Fresh fruit	43	79	94
Fruit juice	26	60	80
Yogurt with fruit	14	43	70

Table 3: Rational (%) for eating more fruit; change in rational (\pm from 2006 to 2010)

Rational/Reason	Rational	Rational change 2006 to 2010 (%)
Good for health/healthy alternative	71	+6
Like the taste	41	+5
Good value for money	26	+1
Improved quality availability	21	+1
More availability all year round	18	-2
Easy to prepare and cook	13	-9
Already prepared	11	+1
Cheaper now	8	-1
Conveniently packaged	8	No change
Change in life stage/situation	7	+2

Outcomes: daily portions and 5-a-day

Persons surveyed were given cards with three pictures of apples. Picture 1 was half a large apple, picture 2 a large apple, and picture 3 two large apples. Seventy five percent of the 796 participants picked the correct picture, i.e. the large apple. Twelve percent chose the half apple and 13% could not make up their minds about the two-apple picture. Consumers’ level of awareness of the 5-a-day message improved significantly in 2010 versus 2006 (Table 4) with 70% (in 2010) saying that five was the recommended number, i.e. awareness doubled in the 2010-2006 period. Consumption also lifted with 45% of the test group (796 persons) eating five or more portions per day compared with 34% in 2006. The 55% of people (438 persons) not consuming 5 portions per day were asked for reasons and responded as shown in (Table 5). Presumably the comments ‘don’t have time’; ‘too difficult to prepare’; ‘limited cooking skills’ refer to vegetables as most fruit are consumed raw rather than cooked, whereas the opposite is the case for vegetables. ‘Lack of awareness’ and ‘forgetting’ accounted for almost 50% of the reason for not eating 5-a-day (Table 5).

Table 4: Ideal versus actual fruit (F) & vegetable (V) intake per day (% of persons citing different numbers of portions per day)

Portions/d	Ideal number of FV portions/d		Actual number of FV portions/d	
	2010	2006	2010	2006
6+	8	8	11	20
5	70	50	34	14
4	9	14	16	24
3	8	19	19	22
1-2	5	9	20	20

Table 5: Reasons (% of 438 persons)^a cited for not consuming 5-a-day

Reasons cited	%	Class/group of person
Did not realise I was not eating enough	33	No particular group
Prefer other foods	23	<24 years; blue collar households
Did not remember to eat 5/d	14	Mostly female
Don't like eating fruit	13	Mostly males
Don't like eating vegetables	10	Mostly males <44 years
Don't have time	9	Females with children
F & V storage at home leads to waste	6	No particular group
Expensive/poor value for money	5	No particular group
Too difficult to prepare	5	No particular group
Limited cooking skills	4	Mostly males

^aSome persons gave more than one answer

Outcomes: fresh produce shopping behaviour

The majority of grocery shoppers claim to buy a broad range of fruit & vegetables and purchase a largely similar range each week. The majority (66%) like browsing in the fresh produce section of the store. About 50% claim they like to experiment in the cooking of vegetables and 80% are confident of their cooking/preparation skills. About 33% know what fruit & vegetables they want before they go shopping but volume purchased depends on the volume required until the next shopping day. Over half (51%) of the consumers choose based on the display available and its apparent freshness, and also cultivars that they think will taste to their families' liking. About one fifth (21%) of consumers purchase based on pricing and by comparing promotions offered. More fresh produce was purchased in 2010 than in 2006 (↑4%) whereas less canned (↓4%) were purchased in 2010; frozen purchases remained static in this period. Frozen fruit had a sizeable rejection cohort amongst grocery shoppers. Non-price factors encouraging increased purchasing (% of 525 persons) of fruit were: increased availability of Irish types (37); awareness of other types (35); free sampling in-store (30); availability of information on other types/ranges/varieties (29); recipes using other varieties/ranges/types (24%).

Consumers are classified as adventurous, habituals and needs-satisfiers (Table 6). Average spending, attitudes and triggers for purchase are listed in Table 6. Purchasing variety, confidence in preparing, and awareness of new produce types are the hallmark of adventurous consumers. The behaviour of habituals does not change much and they are more conservative than adventurous consumers. Needs-satisfiers buy some key items each week but the FV purchased are usually the same.

Table 6: Consumer type: fresh produce segmentation

	Adventurous (21%)	Habituals (45%)	Needs satisfiers (34%)
	Highest number of types purchased	Average number of types purchased	Lower number of types purchased
Average spend	€30	€28	€21
Attitudes	Buy broad range of FV✓	Buy broad range of FV✓	Buy same FV each week✓
	Experiment with new cvs✓	Buy same FV each week✓	Few key veg. bought each week✓
	Enjoy browsing FVs in-store✓	Experiment with new cvs✓	Don't experiment with new cvs x
	Confident to cook & prepare FV✓	Confident to cook & prepare FV✓	Don't buy broad range of FV
Triggers to increase range	Greater availability of Irish types✓	Price✓	Price✓
	Awareness of new types✓	Recipes✓	Sampling in-store✓
	Recipes✓	Awareness of new types✓	

Outcomes: information; health aspects; preparation & cooking

Consumers' desire for knowledge and information on the label of produce has grown between 2006 and 2010. Over 50% are very interested in health benefits and a further 40% are fairly interested. Circa 20% said FV are an important part of a healthy diet and in terms of weight management 13% said suitable while over 25% recognised produce as 'not fattening'. Seasonality is also important for consumers as are convenient recipes.

Fruit is considerably under-utilised in terms of cooking. Very few consumers associate it with versatility or being good for imaginative cooks. Fruit is being 'pigeon-holed' as a category to eat fresh and not as cooked. This is a move away from traditional usage when a number of cooked items, e.g. stewed apple, were commonplace with Irish consumers.

Conclusions

Outcomes from consumer surveys on fruit and vegetables conducted in 2006 and 2010 were compared. There was an increase in fruit consumption in the 3-year period and consumers were more aware of the reasons as to why they should eat fruit. There was also a greater awareness of the 5-a-day target and what constituted a portion. Consumers were classified as adventurous, habituals and needs-satisfiers. Purchasing variety, confidence in preparing, and awareness of new produce types are the hallmark of adventurous consumers. The behaviour of habituals does not change much and they are more conservative than adventurous consumers. Needs-satisfiers buy some key items each week but the FV purchased are usually the same. Consumers' desire for knowledge and information on the label of produce grew between 2006 and 2010 and fruit is considerably under-utilised in terms of cooking.

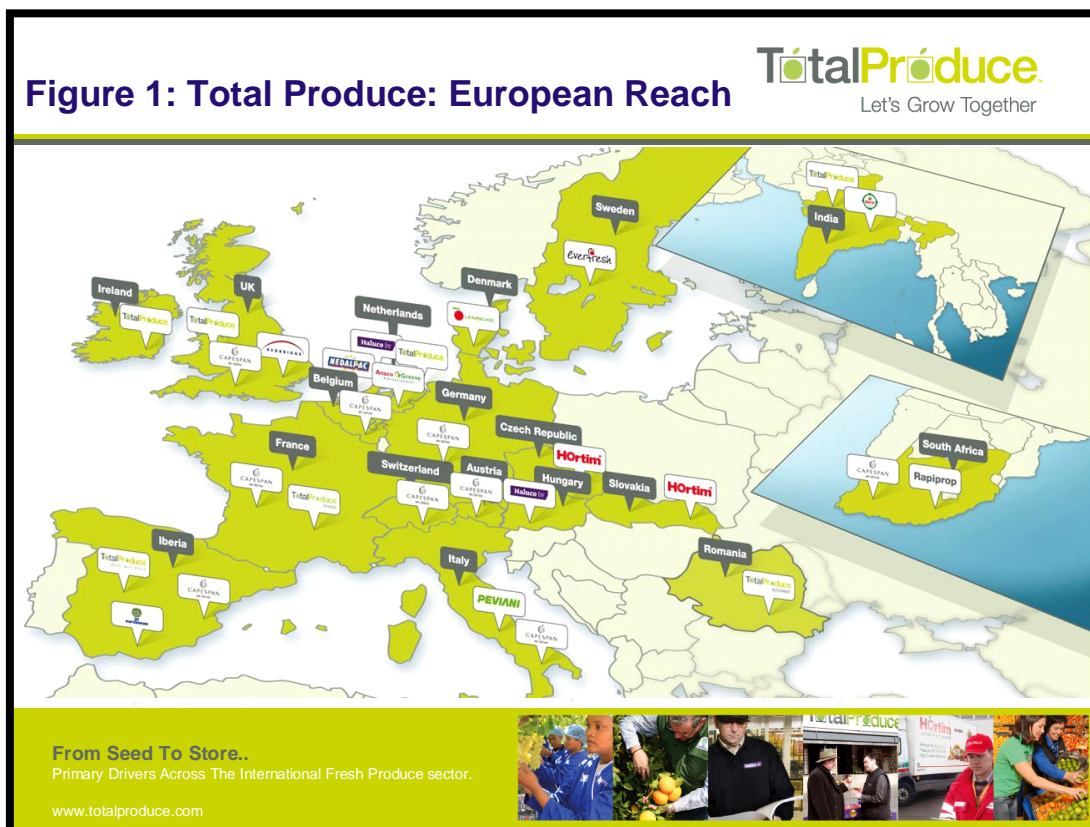
From seed to store: Primary drivers across the international fresh produce sector

Vincent Dolan, Total Produce plc, Rampart Road, Dundalk, Ireland
e--mail: vdolan@totalproduce.com

The produce business has developed from local level, to regional level, to international level, to European level and now to a global level and Total Produce plc is involved globally. The presentation addresses four areas, (i) business of Total Produce plc; (ii) factors determining what's in the European 'fresh produce basket'; (iii) current production and market trends; and (iv) S.W.O.T. (strengths, weaknesses, opportunities, threats) analysis for the European fresh produce sector.

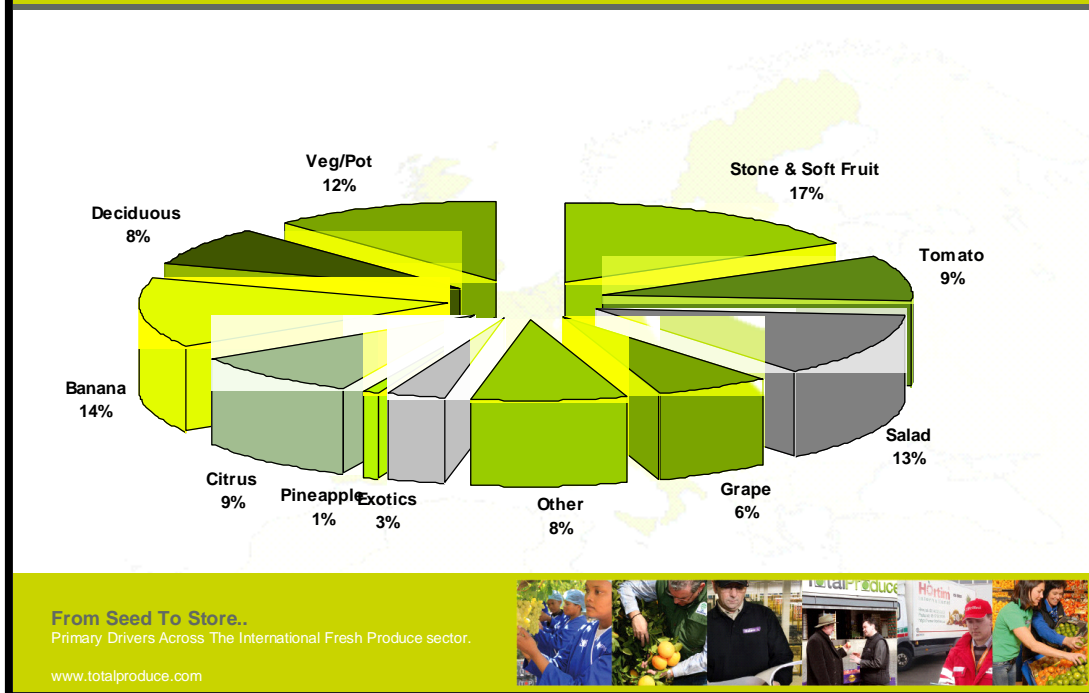
Total Produce (TP) plc

Three years after its formation TP is now at the forefront of the European industry being operational in 19 European markets, with 200⁺ lines, 4,500⁺ employees, 250 million cartons and €2.4 billion turnover. TP is the largest consolidator of Irish salad and fruit & vegetable produce and is market leader in Ireland, Spain, the Czech Republic, Sweden, Denmark, and the UK; its European reach is shown in Fig. 1.



The TP product mix is shown in Fig. 2 with stone and soft fruit representing the biggest segment followed by bananas, salads, vegetables and tomatoes. The produce is obtained from locations around the world depending on season and other factors.

Figure 2: TP: Produce portfolio



Adding value to the supply chain

The TP supply chain involves three segments, i.e. the grower, produce supply/management, and the customer. The three areas require careful integration and this is part of TP's role.

Growers: They must receive agronomic and technical support in order to achieve good levels of production. This requires specification application, promoting good agricultural and logistical practices, seed-store quality assurance co-ordination, and legislative overseeing. Produce supply must be continuous and of high quality. This requires global and local producer selection, organisation of grower groups, administration of supply bases, accreditation verification, producer auditing, supply and demand synchronisation, and streamlining production and export procedures.

Produce supply/management: Quality assurance is key and includes integration from seed to store, quality control, and grading. Packaging considerations include packaging market/client customisation, quality control, and taking on-board new developments in packaging technology. Marketing involves branding, producer/TP/own label, sales promotion management while sales entails client negotiations, claims/credit control, and ordering/administration. Storage and distribution are key TP functions and include modern refrigeration, ripening, storage, product assembly and distribution facilities. The reach is Europe-wide and includes understanding market segmentation, and retailing/wholesaling/foodservice.

Customer requirements and care: This involves commercial and category management elements. The former includes forecasting, consolidation of demand, leveraging collective buying power, price modelling/margin maximisation, and contingency management. The latter includes range/season/portfolio management, on-

the-ground sales, quality assurance support, promotion and packaging design, product and competitor benchmarking, and new product development. The TP core trading principle is that (i) collective procurement delivers superior value, (ii) collective resources deliver more consistent produce, and (iii) diverse core competencies deliver collective expertise at local level.

Produce/fruit industry drivers

The international fresh produce market conventional external drivers include climate, production volumes, quality and demand. Cognisance of currency fluctuations in market versus producer areas is critical as are fuel prices which affect distribution costs. Socio-demographic changes have a major impact and relate to corporate social responsibility, fair-trade, organics, local produce, consumer trends (superfoods, e.g. blueberries), societal changes (convenience products, expendable income) and distribution channels (wholesale vs retail vs foodservice). Emerging external drivers embracing the economic downturn involve (i) macro-environmental factors and, (ii) industry specific implications. The former (i) includes credit and credit control, insurance, risk aversion, and land value, i.e. fruit and vegetable production vs commercial development. The latter (ii) includes price and margin sensitivities, promotional models, trading down, distribution channel movement and food security.

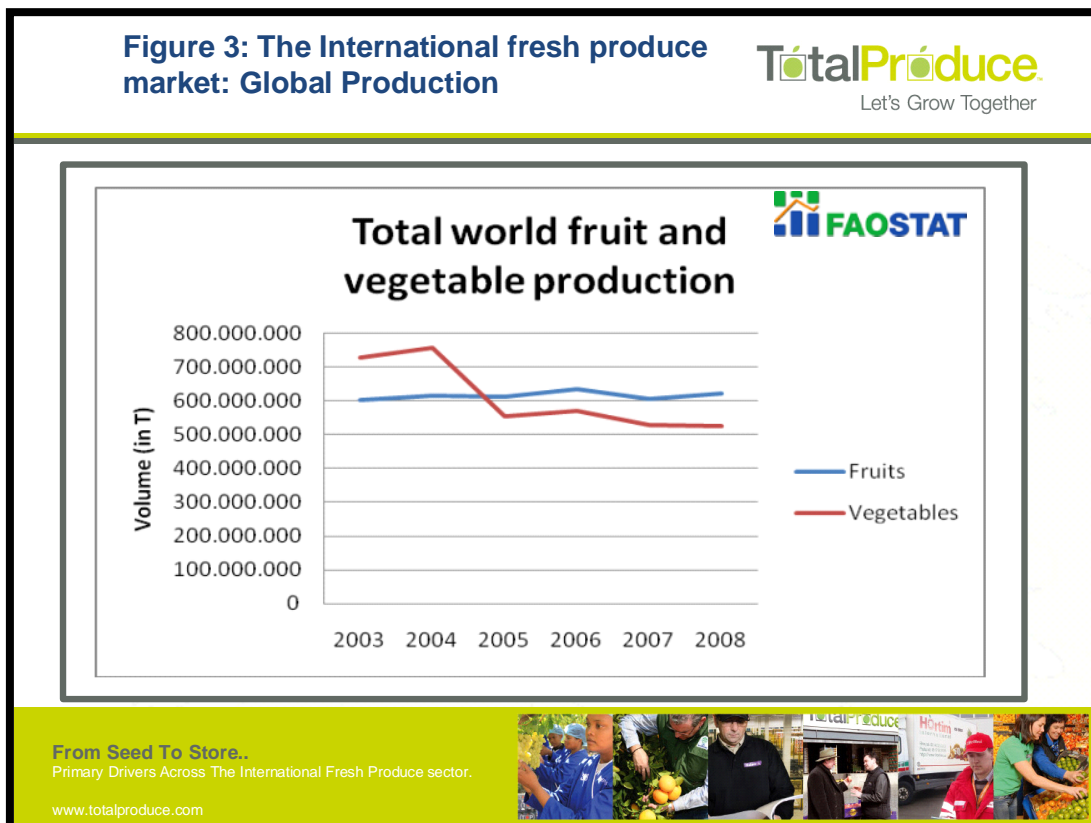
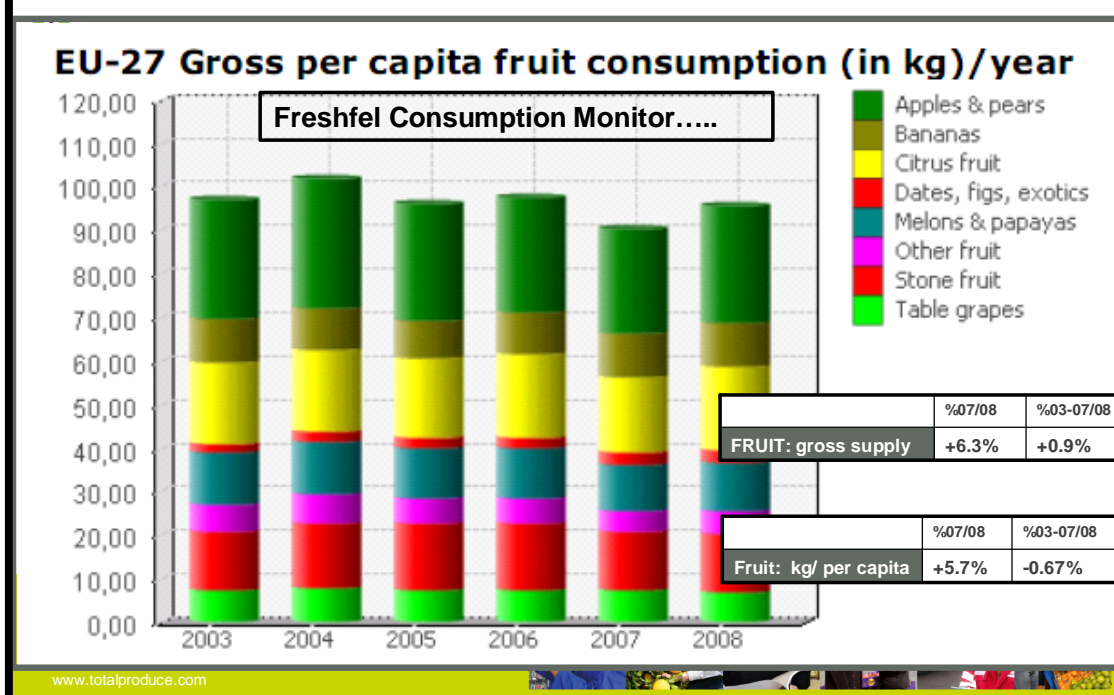


Figure 4: The European fresh produce market: Consumption patterns



Production and market trends

The global production of fruit increased marginally over the period 2003-2008. Vegetable production fell significantly during the same period (Fig. 3). Changes in global fruit prices over the period 2004-2009 were +17.5% (melons), +14.3% (grapes), +13.5% (pears), +5.1% (oranges), +1.3% (bananas), +1.3% (apples), -25.1% (pineapples) and -29.1% (kiwis). The fall in price for kiwi fruit is most likely due to more extensive production and hence greater fruit availability. European fruit consumption has ranged from a high of circa 102kg/capita in 2004 to a low of 90kg/capita in 2007 over the 5-year period 2003-2008 (Fig. 4). Consumption of individual fruit types did not change dramatically during this period (Fig. 4) and 13/27 European countries had fruit consumption below the level recommended by the World Health Organisation (WHO) (Fig. 5). Level of satisfaction (% of satisfied consumers in 27 EU countries) was 28% (overall price), overall quality of service (38%), and overall trust (47%).

SWOT analysis

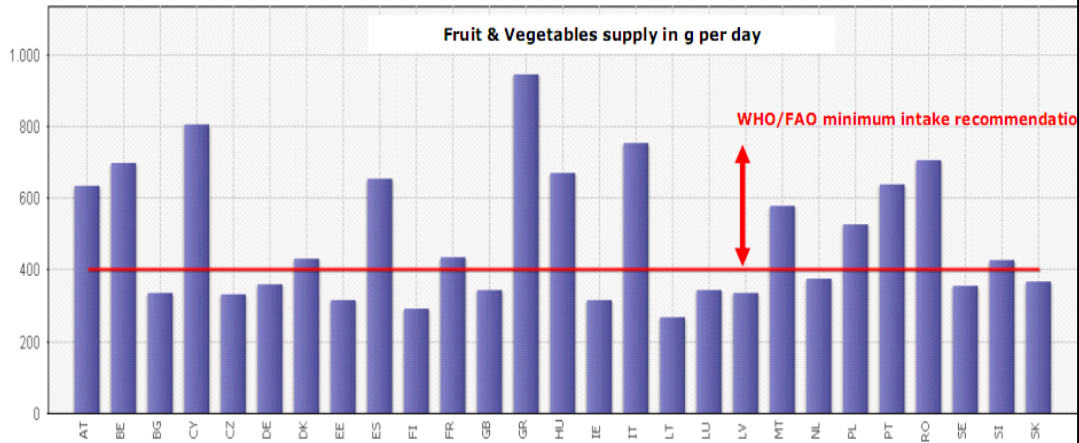
A SWAT analysis of the EU fresh produce sector is presented in Fig. 6. The main strength is that fruit is an inherently good product. Enlightened consumers know this but the message has to be got home to many indifferent consumers. This leads to the main weakness, i.e. stagnated consumption, i.e. that fruit and vegetable consumption is not increasing despite the fact that many consumers fall short of the WHO guideline of 400g per day intake of fruit and vegetables. This gives rise to an opportunity, i.e. increased promotion of fruit and vegetable consumption by national governments and the EU. The requirement for this was never more pressing in view of the need for dietary change in a European society which is becoming increasingly obese; increased fruit and vegetable consumption can help combat obesity. The main threats arise from

Figure 5: Fruit consumption (27 EU countries)



Freshfel Consumption Monitor.....

13/27 countries were < 5 fruit/d



From Seed To Store..
Primary Drivers Across The International Fresh Produce sector.
www.totalproduce.com



Figure 6: EU Fresh Produce Sector: SWOT Analysis

<p style="text-align: center;">Strengths</p> <ul style="list-style-type: none"> • Inherently good product • Diversity & flexibility • Industry resilience • Provenance 	<p style="text-align: center;">Weaknesses</p> <ul style="list-style-type: none"> • Stagnated consumption • Fragmented supply base • Price perceptions/misinformation • Marketing potential vs substitute FMCG goods; Commodity ?
<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> • Governmental & EU Promotion • Prevailing consumer sentiment • Advances in product provision; range, availability, quality, freshness • New Markets; Russia, China, India 	<p style="text-align: center;">Threats</p> <p style="text-align: center;">Unsustainable pricing / Reconditioned consumers ?</p> <ul style="list-style-type: none"> • Credit restrictions • Escalating underlying costs • Food security & local production

From Seed To Store..
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unsustainable pricing and from consumers who are being brainwashed by food adverts for prepared consumer foods and junk foods. Currency fluctuations and

fluctuating fuel prices are also major threats. For example, the strength of the Euro against Sterling caused massive difficulties for Irish produce exporters. Similarly, worldwide currency fluctuations make produce pricing very difficult and may make produce prices at retail outlets seem high to the consumer. All these factors militate against profitability and give rise to market uncertainty. Similarly increased fuel charges have major impact on the international movement of produce. Despite these influences the value of the Irish produce market fell by up to 9% through price deflation in the period February 2009 to February 2010, i.e. fruit and vegetable prices were never lower in real terms.

Conclusions

The European fresh produce sector is of immense commercial and social value. It is delicately balanced, often threatened but has massive potential. Failing to harness this would be a major lost opportunity. Promotion must be both strategic and tactical and we need collective solutions to collective problems.

Produce Retail concepts

Shaun Doherty, Tesco Ireland, Dublin

e--mail: shaun.doherty@tesco.ie

Introduction

Customers feedback suggests the ‘every little helps’ and fruit must be safe, healthy, in-season, right price, good tasting, look good when taken home, produced ethically, and must not affect the environment adversely. In the current recession consumers are belt tightening and so produce prices must be attractive to maintain or increase sales levels. Tesco have four store formats, i.e. express, metro, superstores, and extra. The Tesco focus on produce embraces eight dimensions: (i) sourcing right locations and suppliers; (ii) do more locally in season; (iii) Irish customer panels, what are their needs; (iv) innovate more in new product development; (v) ensure that specifications are fit for market; (vi) manage stores more effectively; (vii) up skill produce staff; and (viii) make it easier for stores to handle produce.

Sourcing produce

Fruit and vegetables are sourced on a global basis including China, Czech Republic, Hungary, Ireland, Japan, Malaysia, Poland, Slovakia, South Korea, Thailand, Turkey and the United Kingdom. Specific apples such as Pink Lady are sourced in many locations to ensure year-round supply, i.e. Chile (San Fernando and Temuco),

Figure 1: Royal Gala: Altitude is critical in areas highlighted for new supply to provide for adequate winter storage. Optimum growing at 42-50° latitude



Argentina, South Africa, Australia (Perth and Adelaide) and New Zealand. Similarly for the cultivar Royal Gala (Fig. 1). Another example is JazzTM which is a fresh crunchy apple with good sweetness, juiciness, and a flavour reminiscent of pear drops. Jacques Timmerman is one of a selected group of growers from around the world who have been selected to produce JazzTM. This apple has only been permitted for planting in ideal growing locations to ensure it delivers an exceptional eating experience ----- see more on www.jazzapples.co.uk Irish grown produce for Tesco is grown according to Bord Bia quality standards and produce from other countries to standards prevailing there. Tesco personnel make frequent visits to suppliers and conduct systematic microbiological and chemical testing on fruit and other produce.

Tesco quality focus

The focus is on seven main areas:

- Quality at the right price
- Produce Planograms so that the right products are together
- Refrigeration applied only to fruits that benefit from it; e.g. not to bananas
- Chill chain assurance
- Date coding and control of product on-shelf
- Availability - - can I get what I want?
- Store staff product knowledge; continuous training due to high staff turnover

Future growth areas, e.g. healthy eating

This includes:

- Nutritional signposting --- informing consumers of the good and not so good
- Super foods --- such as blueberries
- Organic fruit --- ensuring origin/authenticity
- Education --- highlighting the health benefits of fruit and vegetables
- Fresh and local --- where possible this is the case --- emphasise to customers

Conclusions

Tesco Ireland operates to the highest standards regarding its food products including produce. Where possible (season etc), produce is sourced locally (to top quality standards) to ensure freshness and give consumer satisfaction. In the case of apples, exotic fruits, and conventional fruits that are sourced abroad for reasons of seasonality, great care is taken to choose growing regions most suited to delivering top quality, and then to transport, storage and retailing conditions most suited to maintaining that quality. Display in-store is also very important re sales and image as are promotions and consumer education on the health benefits of fruit and vegetables and of the desirability to increase daily per-capita intake. Pricing and perceived value for money are also extremely important.

Discussion and Consensus Statement on Fruit and the Consumer

It was agreed that more than a good health image is necessary to increase fruit consumption, i.e. the availability of good cultivars together with top quality, good distribution, good presentation at retailing, coupled with attractive promotion and pricing are also key factors. The mapping of the fruit preferences of European consumers was considered very important and the need for a greatly increased research input in this area was recommended. The importance of feeding this information back to fruit breeders is of paramount importance in order to better guide breeding programmes.

The extent and importance global reach of the produce sector is underestimated by many producers at local level and also by consumers. It was agreed that such a reach is necessary in order overcome seasonality and to supply consumers with the excellent range of fruits to which they have become accustomed. Fruit prices are likely to rise over the next few years despite the recession currently prevailing in Europe. This is due to increasing transport costs and the effects of currency fluctuations when buying produce from many different countries worldwide.

Outcomes from consumer surveys on fruit and vegetables conducted in 2006 and 2010 indicated that there was an increase in fruit consumption in the 3-year period and consumers were more aware of the reasons as to why they should eat fruit. There was also a greater awareness of the 5-a-day target and what constituted a portion. Consumers were classified as adventurous, habituals and needs-satisfiers. Consumers' desire for knowledge and information on the label of produce grew between 2006 and 2010 and fruit is considerably under-utilised in terms of cooking.

Supermarkets in Ireland operate to the highest standards regarding food products including produce. Where possible (season etc), produce is sourced locally but most apples, exotic fruits, and conventional fruits are sourced abroad. Display in-store is very important for sales and image as are promotions and consumer education on the health benefits of fruit and vegetables. Pricing and perceived value for money are also extremely important.

CONSENSUS STATEMENT: The quality of fruit and vegetables available for the Irish consumer is excellent. In this context having the 'right variety' for the 'right consumer' is critical. Consumers are increasingly aware of the health benefits of fruit and vegetables but there is no room for complacency and intakes must be increased through greater promotion and attractive pricing.