



Use of potato processing by-products

The five papers described below investigated various ways of utilising the waste from potato processing operations.

In Canada and the United States approximately 30 million tonnes of potatoes are grown per year. About half of this is by-product, e.g. cull potatoes and potato processing waste, which is not suitable for human consumption. Liquid waste can be applied to crops, such as maize, vegetables and grass, under strict environmental monitoring and control. Solid waste and culls are often disposed of in landfills or



applied as fertiliser on agricultural land. However, the research described in the first paper (Charmley et al.) has shown that potato processing waste can be used as a high-quality animal feed, principally in beef feedlots. It can replace up to 80% of maize and barley grain without negative effects on animal growth rates or quality, and can actually improve efficiency of animal growth per unit of diet intake.

The second paper (Koen et al.) discusses ways of treating potato processing effluent using case studies to illustrate the issues raised. Particular reference is made to the composition of potato processing effluent, treatment options and financial benefits of efficient treatment processes.

A symposium entitled "Organic waste to resource: recycling nutrients" was held at the joint meetings of the Soil Science Society of America and the Canadian Society of Soil Science in Seattle, Washington, USA, 31 October–4 November 2004. Six papers from this symposium have been published in the Canadian Journal of Soil Science (Larney & Pan) and cover a range of organic by-products, including potato processing. The papers cover nutrient contents, forms and dynamics and discuss soil response to the recycled organic by-products and subsequent crop performance. Other important issues, such as handling, the environment and regulations, are also considered in relation to these by-products.

With worldwide concerns about energy shortages, there has been an increase in research about utilisation of potato by-products as an energy source. The paper by Parawira et al. describes a pilot study of a simple two-stage anaerobic digestion process for solid potato waste and sugar beet leaves, both separately and in co-digestion. The latter gave up to 60% higher methane yield, with a biogas of 60–78% methane content.

The fifth paper (Zhu et al.) also investigated a two-stage anaerobic digestion process, producing hydrogen and methane from potato waste. The hydrogen stage operated at a pH of 5.5 for 6 hours, and was followed by the methane stage at pH 7 for 30 h

Potato goes back to its roots

DNA from herbarium specimens settles a controversy about origins of the European potato. There have been competing theories about whether the "European" potato originated from the high Andes or from lowland Chile.

Over the last 60 years, the Andean origin has been widely accepted. Recent DNA studies indicate that the Andean potato predominated in the 1700s but the Chilean potato was probably introduced into Europe around 1811, before the UK late blight epidemics that began in 1845. Chilean germplasm has been widely used since then to produce the modern potato cultivars. *Ames & Spooner (2008) American Journal of Botany 95: 252-257.*

and 90 h, for continuous and semi-continuous flows, respectively. The average hydrogen concentration was 45% and the methane concentration was 76%. The hydrogen and methane yields from the potato waste were 30 and 183 litres/kg, respectively, with an average total energy yield of 2.14 kW h/kg.

Nutrient cycling in the vegetable processing industry: utilization of potato by-products.

Charmley et al. (2006) Canadian Journal of Soil Science 86: 621–629.

Treating potato processing wastewater. Koen & Clayton (2007) Food Review 34: 36–39.

Organic waste to resource: recycling nutrients.

Larney & Pan (2006) Canadian Journal of Soil Science 86: 585–653.

Energy production from agricultural residues: high methane yields in pilot-scale two-stage anaerobic digestion.

Parawira et al. (2008) Biomass and Bioenergy 32: 44–50.

Co-production of hydrogen and methane from potato waste using a two-stage anaerobic digestion process. Zhu et al. (2008) Bioresource Technology 99: 5078–5084.



Cultivars and plant breeding

Powdery scab is caused by the pathogen *Spongospora subterranea*. The three papers described below investigate relationships between soil contamination and disease incidence and severity, as well as looking for potentially resistant cultivars.

► **Willamette: A chipping cultivar with high yield and specific gravity, low incidence of hollow heart and brown centre, and suitability for fresh-market usage.** This cultivar was selected in Powell Butte, Oregon, and released in 2003 by the Oregon, Idaho and Washington Agricultural Experiment Stations and the US Department of Agriculture-Agricultural Research Service. Willamette is a relatively large, vigorously-growing plant with medium-late maturity. Compared with cv. Atlantic, Willamette tended to have higher yields and fewer internal tuber defects along with lower levels of total glycoalkaloids and vitamin C. Chipping performance was good after storage at 10°C but not 4°C. Willamette had greater resistance to Verticillium wilt and potato leafroll virus, similar susceptibility to early blight, foliar late blight, Erwinia soft rot and potato virus Y, and greater susceptibility to tuber late blight and common scab than Atlantic. *Mosley et al. (2008) American Journal of Potato Research 85: 85–92.*

► **Varietal susceptibility of potatoes to wireworm herbivory.** This study describes a range of experiments, from laboratory to large-scale field trials, that tested over 2000 tubers from 12 varieties, examining their susceptibility to herbivory by wireworms (*Agriotes* spp.). Three varieties, Maris Peer, Marfona and Rooster, were significantly more susceptible to wireworm attack (63% of tubers showing damage) than King Edward, Nadine and Maris Piper (15% tubers damaged) in laboratory no-choice tests. In choice tests the susceptible varieties had 4.2 holes per tuber compared with 1.2 holes per tuber for the least susceptible varieties. Similar patterns of susceptibility were seen in the field trial. Although Nadine had the highest glycoalkaloid concentration and lowest wireworm herbivory, over all cultivars the relationship between wireworm susceptibility and glycoalkaloid concentrations was weak. *Johnson et al. (2008) Agricultural and Forest Entomology 10: 167–174.*

Intragenic crop improvement: Combining the benefits of traditional breeding and genetic engineering. This paper discusses the process of intragenic crop improvement, where genetic modification techniques are used but only DNA from the same species is transferred from one breeding line or cultivar to another. The DNA elements being transferred are well characterised so that any inadvertent transfer of undesirable DNA is prevented, which may not always be the case with transgenic technology. Intragenic techniques mean that specific beneficial traits can be transferred or enhanced while undesirable characteristics can be silenced. The paper describes an example of an intragenically-manipulated potato plant where three genes were altered, resulting in tubers that produced French fries with greatly reduced amounts of the suspected carcinogen acrylamide, an enhanced flavour and the absence of discolorations. The paper argues that intragenic modification is similar to traditional breeding and is unlikely to result in variation that is new to the species. Therefore an updated regulatory system should be adopted so that intragenic crops are considered low-risk and can be cleared for commercial release in a timely and cost-effective manner. *Rommens (2007) Journal of Agricultural and Food Chemistry 55: 4281–4288.*

► **Genetically modified organisms in crop production and their effects on the environment: methodologies for monitoring and the way ahead.** This report of an FAO expert consultation examines strategies for assessing the effects of GM crops on the environment. It comprises two parts, a summary of recommendations from expert groups and 13 papers presented by invited speakers. One of these papers examined approaches and challenges in conducting risk assessment and monitoring in New Zealand, while another looked at hybridisation between wild and cultivated potato species in the Peruvian Andes and biosafety implications for deployment of GM potatoes. *Ghosh & Jepson, eds. (2006). Expert consultation 18–20 January 2005. Report and selected papers. FAO, Rome, Italy.*

Nutrition

► **Determination of folate concentrations in diverse potato germplasm using a trienzyme extraction and a microbiological assay.** The research described in this paper measured the total folate concentrations of potato tubers from 67 cultivars, advanced breeding lines, or wild species. There was variation in the folate concentrations (521–1373 ng/g dry weight) and this was dependent on genotype and location. Highest folate concentrations were found in potatoes with

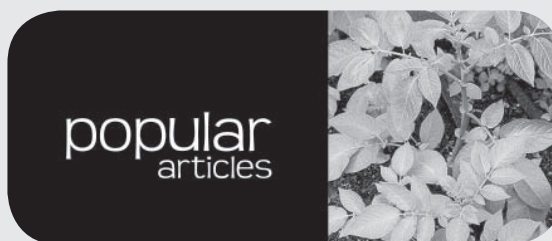
coloured flesh. The folate concentration of skin varied from being the same as the flesh to being 2-fold greater. Folate concentrations tended to increase during a 7-month storage period. *Goyer & Navarre (2007) Journal of Agricultural and Food Chemistry 55: 3523–3528.*

► **Anthocyanin fraction from potato extracts is cytotoxic to prostate cancer cells through activation of caspase-dependent and caspase-independent pathways.**

Polyphenols show anti-cancer properties, and polyphenols such as phenolic acids and anthocyanins have been found in high concentration in specialty potatoes. The effects of various phenolic fractions on two prostate cancer cell lines were investigated in four specialty potato cultivars. Extracts from cultivar CO112F2-2, particularly the anthocyanin fraction, inhibited cell proliferation and other cell functions in both cell lines. Various cellular pathways that mediated this effect were examined and future research will look at developing potato cultivars that overexpress the active anthocyanin compounds. *Reddivari et al. (2007) Carcinogenesis 2007 28(10): 2227–2235.*

► **Glycemic index – a review and implications for the potato industry.**

Potato has a number of positive nutritional characteristics: it has no fat, is rich in vitamin C and potassium, and a good source of dietary fibre. However, the starch of cooked potato is rapidly broken down to glucose, which results in a rapid elevation of blood glucose after food products containing potato have been consumed. This leads to a moderate to high glycemic index (GI), a value used as a clinical indicator of the suitability of a food for consumption by diabetics. Ranking of foods by GI is recommended by the World Health Organization and numerous diabetic associations worldwide. An alternative parameter, glycemic load (GL), takes into account the amount of carbohydrate consumed per serving, and because potato tends to have a high moisture content, the GL of potato is generally moderate. GI and GL differ between cultivars and can be modified by processing methods, and GL can be also modified by other components of the meal. Therefore, further research is required to accurately define these values for specific cultivars and processing conditions. *Lynch et al. (2007) American Journal of Potato Research 84: 179–190.*



www.spudman.com

► **Controlling *Verticillium*: early identification can prevent early die in following years.**

Verticillium dahliae is the pathogen that causes Verticillium wilt, one of the main components of potato early die disease. The fungus is difficult to control because of microsclerotia, which are infective structures that may survive in the soil for up to 15 years. The fungus infects the root tip and travels up the plant, producing a toxin that disrupts the vascular system and stops water reaching the plant leaves. Some potato varieties are resistant to the disease, but Russet Norkotah is very susceptible, with plant death occurring within 7 weeks of infection. Because of the long survival period, prevention is particularly important in clean fields. It is essential to identify the disease in first-year potato crops because in subsequent years there can be a rapid increase in infection in the field. Fumigation and other control measures, such as planting certified clean seed, will help to limit spread of the disease, as does cleaning machinery and equipment between potato fields. Another control measure is ensuring that the potato fields remain free of weeds that may also be hosts to the disease. *Verticillium dahliae* infects a wide range of plants, but some strains are more aggressive on potatoes. A survey of 224 seedlots in 18 states in the USA found that 29% had *Verticillium* infection, with two-thirds being the aggressive VCG4A strain. *April 2008, p. 14.*

► **Saving good fungicides: fungicide resistance management grows ever more important.**

When a pathogen develops resistance to a fungicide, the implications are huge. It may take several seasons for the resistance to be detected, and during that time reduced efficacy will cause significant economic losses for growers. In the past, there was a steady stream of new fungicides coming on to the market, so the loss of one particular chemical due to resistance did not have a major impact. However, the development of new chemicals has slowed dramatically and the costs of launching them have escalated. This means it is very important to protect fungicides so that they do not lose their effectiveness. Plant pathologists have been particularly proactive in this area, forming the "Fungicide Resistance Action Committee (FRAC)", which helps to form fungicide resistance management strategies and provides recommendations to growers and the industry in general. Because many of the older



fungicides have multiple sites of action against the pathogens, they are actually less likely to develop resistance. The multi-site chemicals have been given a FRAC code of M and there are 9 classes of M fungicides. In addition there are 43 other FRAC groups and these are rated as high, medium or low risk of developing resistance. The FRAC codes enable growers to identify relationships between fungicide classes and thus the potential for developing cross-resistance. Rotating fungicides between chemical groups is a key strategy in preventing resistance. Resistance management guidelines are available at www.spudman.com (and those specifically for New Zealand conditions are available at www.nzpps.org). *April 2008, p. 16.*

Snippets from www.potatonews.com

Listed below are a small selection of the articles that are posted on the Global Potato News website. Please visit the site for further details or follow the links.

► **Early start for seed potato virus protection.**

Scottish seed growers have found that virus spread by aphids (particularly virus A) is occurring earlier in the season and that consequently insecticide applications will need to begin earlier, even before aphids conventionally associated with virus spread have been caught in monitoring traps. It has been suggested that non-colonising aphids (e.g. cereal aphids) are migrating through potato crops and transmitting the viruses. Aphid control may have to start at plant emergence and continue throughout the season. New insecticide products with fast aphid knockdown are available and can be used with other products to minimise the risk of developing resistance. *February 2008: Press Release (Syngenta UK).*

► **Potatoes and the latest nutrition breakthrough: Resistant starch.**

Resistant starch is a type of dietary fibre naturally found in carbohydrate-rich foods, such as potatoes, grains and beans. This starch tends to be formed when these foods are cooled and it appears to "resist" standard human digestion processes. Because the resistant starch is not digested in the stomach and small intestine, the body feels "full" and stimulates release of satiety-inducing hormones. Resistant starch is fermented by bacteria in the large intestine to produce beneficial fatty acids, including butyrate, which may shift body metabolism away from utilising carbohydrates towards using stored body fat for energy. *February 2008: Feature Articles.*

► **Evaluation of novel seed treatments in combination with management practices for the control of seed-borne diseases of potatoes.**

This poster (<http://www.potatodiseases.org/pdf/APS-2007-seed-treatment-poster.pdf>) summarises research from Michigan State University that looks at two new bio-fungicides (*Bacillus subtilis* and *Trichoderma hazianum*) and a reduced risk fungicide (fludioxonil + mancozeb) for control of late blight and Fusarium dry rot diseases. Tubers were inoculated with the pathogens, followed 30 minutes later by the fungicide treatments. Tubers were cut and treated then either stored for 10 days before planting, or planted directly after treatment. Under optimum storage conditions, both bio-fungicides gave good control of sprout rot and seed piece decay caused by *Fusarium sambucinum*. The incidence of seed piece decay from late blight was also lowered by the bio-fungicides. In these conditions, the control from bio-fungicides was equal to the reduced risk fungicide. In field trials, sprout emergence and final stand density from bio-fungicide treatments were not significantly different from positive controls (inoculated but not treated). However, results depended on whether the seed was planted directly after treatment or after storage for 10 days. *February 2008: Feature Articles.*

► **New Zealand: World-first Chip Standards are good for NZers.**

A Horticulture New Zealand press release welcomed the launch by The Chip Group of new industry standards for cooking healthier hot chips. The standards focus on the way they are prepared and cooked, and implementation will greatly reduce the amount of oil used in cooking takeaway chips. It was also an opportunity to remind consumers that potatoes contain vitamins and minerals, and are an excellent source of fibre and carbohydrates. *March 2008: News Headlines.*

► **United States: Scientist says chemical might not be so harmful.**

An external review panel for the Environmental Protection Agency in the USA is drafting recommendations on what is a safe level of exposure to the chemical acrylamide in food. This neurotoxin and carcinogen is formed in food when carbohydrate-rich material that also contains the amino acid asparagine is exposed to high heat such as deep-fat frying or baking. Following the discovery of acrylamide in food in 2002, there has been a huge amount of research into establishing safe exposure rates. In rats, 2 mg per kg bodyweight per day has been shown to cause cancer. It is thought that the human exposure rate will be set at 3 micrograms per kg per day, with most Americans being expected to average an intake of 0.4 micrograms per kg per day. *March 2008: News Headlines.*