Innovations in Australian Food Processing – An Eco-efficiency Perspective

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Abstract

As a matter of necessity, the food industry in Australia, and worldwide, is required to look towards innovative ways to remain competitive and sustainable. The increasing costs of resources and waste disposal are encouraging the industry to rethink ways of doing business and to improve process efficiencies. Such innovative thinking includes adopting a life cycle approach, greening supply chains, designing products and processes to minimise environmental impacts, using new technologies and materials and placing more emphasis on efficient management systems. This paper explores trends in food processing and examines some of the innovative ideas, processes and technologies that have been adopted with particular emphasis on eco-efficiency.

Keywords: eco-efficiency, innovation, food processing, sustainability, environmental impacts, technology

The Food Sector - overview

The food sector is important to most world economies, and is often a significant export earner, especially in the case of many less developed countries (LDCs) and economies which were historically based on primary production. According to the Australian Bureau of Statistics' FoodStats, in 2003-04 Australia's total consumer expenditure on food rose to $89 billion and comprised about 46% of total retail spending, while the value of Australian farms and fisheries production rose to $32.1 billion. Food exports made up $22.3 billion which were 20% of total Australian merchandise exports, placing Australia at about 11th in the league of food exporting nations.

As well as processed export growth, the markets for food products are changing. There have been a multitude of changes in the food markets domestically and internationally from various trends in changing demographics. These include increased urbanization, declining rates of population increase, increased longevity, decline of women as housekeepers, changes in attitudes and values and the increased use of convenience products. Even personal fulfilment needs are changing as a result of the availability of different fresh products, tasty products and healthy natural products. These changes are of course also companied by rapid technological change, increased globalisation and increased acceptance of the 'new'.

To cope with these changes in consumer demographics, needs and expenditure, and increasing export demand, processors are increasingly looking for smarter ways to achieve flexible manufacturing, automation, good practices, hygiene, safety, quality and lowered production costs. Innovation is needed for competitive advantages and new market share.

We suggest that eco-efficiency is one way to bring on board many changes that will improve the overall efficiency and allow growth in a competitive marketplace.

The National Food Industry Strategy (NFIS) has recognized the need for innovation in the sector and has provided aid as grants. A report commissioned by NFIS suggests that the '*innovative capacity of the food industry depends on the complex interaction between the level and range of capabilities at the individual company level, the efficiency and effectiveness of networking and clustering arrangements within the industry and beyond to other industries and knowledge-producing agents and finally the success of public policy in creating favourable conditions for innovation' (AFFA, 2002).*

We consider that an eco-efficiency program represents an avenue for innovation across the many layers between companies, industry clusters and public policy and can add value to the innovation strategy. Here we explore a few innovative eco-efficiency applications that have been successful for a range of food processing sectors.

A Life Cycle Approach

UNEP (the United Nations Environment Program) launched its Life Cycle Initiative some three years ago to encourage all stakeholders to take up a wider and more inclusive view of sustainability issues. LCA enables food processors to evaluate the effect their product has on the environment over the entire life of their product, from the extraction of raw materials through to final disposal of the product. A life cycle assessment usually involves developing a detailed inventory describing all the emissions and raw materials used during the life of the product. An impact assessment then follows to quantify the environmental impacts of these emissions and raw material depletion. Understanding the environmental impacts of a product can assist processors, government and consumers in making informed purchasing and use decisions and identify opportunities for best practice intervention. For example, Dairy Australia has recently supported an LCA study by the University of NSW to identify all environmental impacts along the dairy supply chain in order fully understand the overall system before deciding where best to invest in order to achieve maximum benefit. LCA also enabled the industry to determine what effect any changes would have on different impact categories (Nichols, 2005). LCA can also be a valuable marketing tool and is generally considered one of the more scientific and reproducible decision support aids. Getting accurate data across the lifecycle may help to clear public misconceptions about an industry. Meat and Livestock Australia (MLA) for example is presently funding an LCA study of several areas of the meat supply chain to identify issues and seek to remedy misconceptions, for example in water and other resources use (FSA Consulting, 2005).

Greening supply chains

Supply chain management is a growing and innovative method of controlling impacts, risks and profitability for a company. Improvements in packaging, transportation logistics, efficient inventory management and collaboration between trading partners can result in greater efficiency in resource utilisation and reduced waste and greenhouse gas emissions. It represents a valuable business model that understands the need to deliver consumer satisfaction at the end of the chain and add value to each participant in the chain. The National Food Industry Strategy (NIFS, 2002) has started chain management information and workshop sessions to embed chain management practises in the industry. Environment Australia provides an excellent case study of how a supply chain team for Heinz Watties, a tomato sauce company, identified that loss of product across the chain from poor harvest co-ordination and delivery, to failure to meet quality standards in processing, amounted to a total loss of 56.6% of the tomatoes grown. In addition the team identified that the high level of packaging wastes through the life cycle of tomato sauces could be reduced from 0.57 kg to 0.24 kg per L of sauce by substituting glass with PET. Savings across the supply chain are expected to be greater than $60,000 annually with a payback period of one year. The case study also describes the process of working through the issues with the various stakeholders and the importance of making partnerships work through good cooperation and distributing benefits equitably.

Another recent development in the supply chain is the upsurge in house brands. The concentration of buying power in the hands of two major chains (in Australia) means that they have substantial power to dictate what they will sell to the public. According to an article in The Age, up to 30% of all goods sold in supermarkets are expected to be "generic" in the near future (McMahon, 2005). This has great implications for innovation and eco-efficiency as the chains battle to bring prices down and gain market share. Athukorala and Sen (1996) pointed out that Less Developed Countries (LDCs) were increasing their share of processed food exports. They commented that this growing importance of food export is largely a result of policy regime rather than innate country competitiveness. Again this speaks of the need for export-reliant countries like Australia to be in the forefront in the search for innovation and highlights the importance of the supply chain.

Innovative solutions to improve food processing

As eco-efficiency practitioners, we are always searching for better, smarter ways to do business. The production stage is often where innovative thinking can result in significant financial savings for companies that also reduces their environmental impacts. These interventions broadly fall into the areas of energy, water, waste and management, and we will discuss innovations associated with the first three in this paper.

Energy

Food processors are large users of energy. A survey by the Australian Food and Grocery Council (AFGC 2001) found that energy consumption for some Australian food and grocery companies is higher than relative international standards, indicating that there is scope for reducing energy usage. Innovative opportunities to reduce energy consumption in food processing include exploring alternative sources of energy, cogeneration, heat recovery and optimising the operation of energy consuming equipment.

The utilisation of organic waste through anaerobic digestion, to produce a biofuel is playing an increasingly greater role in renewable energy applications. Food companies that have benefited from the use of this alternative fuel source typically had high heating and effluent discharge costs and possessed existing infrastructure, such as a gas boiler that could utilise the biogas (UNEP Working Group for Cleaner Production, 1999). For example, an upflow anaerobic sludge-bed (USAB) digester at Golden Circle in Brisbane is successfully treating fruit and vegetable effluent to produce biogas for a gas fired boiler. Golden Circle burns approximately 2.5 million m^3 of biogas per year, saving $100 000/yr in coal costs (UNEP Working Group for Cleaner Production, 2003b).

Suncoast Gold Macadamia of Queensland has had similar success in converting waste to energy using thermochemical conversion. In partnership with Ergon Energy, the company burns more than 5000 tonnes of macadamia shells annually in a cogeneration plant to produce steam and electricity. It produces 9.5 GW h of electricity per year, of which 1.4 GW h is used by the plant. The rest is exported and traded in the national electricity market. (Ergon Energy, 2003, Suncoast Gold Macadamias Biomass Co-generation Facility, 2003).

Another innovative way to avoid waste and generate an energy source is to utilise reject surplus heat. The practicality of heat recovery often depends on the distance between the heat sources, the presence of contaminants as well as the potential application. The Butter Producers' Cooperative Federation in Brisbane designed a particular novel way to cool its product while also recovering waste heat by installing jacketed stainless piping on all their product lines. Water flows counter-current through the jacket recovering heat from the liquid butter. Heated water is stored for washdown while product cooling lowers refrigeration costs saving about $8400 annually, and of course the associated environmental burdens (UNEP Working Group for Cleaner Production, 2003a).

Another renewable source that is particularly suitable for Australia's climate is solar energy. Solar systems typically have high initial costs but low operating costs if they are well designed, installed and maintained. For example Novartis Consumer Health in Victoria, a chocolate and coffee processor heats water to between 50^{o}C and 60^{o}C using solar panels. A gas booster heater increases the temperature a further 20^{o}C.

Despite constant research and with innovations appearing regularly, solar voltaics have not yet made significant inroads to the food processing community (SEAV, 2003).

As mentioned previously Suncoast Gold Macadamia uses a cogeneration system using a single source of fuel to produce both electrical and thermal power. The efficiency of these systems can be as high as 80% because the energy is being extracted from the system in the form of both heat and power. The payback period is typically around 3-4 years, however if a waste stream can be utilised as in the case of Suncoast Gold Macadamias, additional savings can be made.

Adelaide Malting in South Australia produces malted barley for the beer brewing industry. The company recovers heat from its gas engines (used to drive its fans) to heat the malt drying air. The initiative to change from electric-powered fans and drying equipment saves the company over $70000 annually and has boosted plant capacity by 20%. The payback period was two years (Environment Australia, 2001a).

Waste reduction and value adding

Innovative waste solutions in the food processing sector are seeking to reduce the environmental, social and financial costs of treatment, collection and disposal of waste. Potentially valuable resources are utilised through product recovery, extraction of by-products, recycling of waste products and the development of new products. Advances in membrane technology are continuously coming on stream and have opened the way for many exciting opportunities in product recovery for the food processing industry and in new product manufacture. The main advantages of membrane plants are their ability to separate substances in a chemically unchanged form with low energy consumption. For successful application it is essential to know the quality requirements of the recovered substances and the characteristics of the feed stream, along with the conditions under which the membranes will have to operate. The dairy sector has been a front runner in developing applications for membranes and now the water supply and treatment industry is starting to benefit from more reliable technology and lower costs.

The recovery of product by process modification can result in considerable savings in product as well as a reduction in the volume of solid waste and associated disposal costs. Warrnambool Cheese and Butter in Allansford for example recovers milk permeate from an ultrafiltration plant to standardise milk powder. Almost 100% of the milk permeate is utilised for standardising and any excess permeate is sold to other dairy companies. The payback period for the project was 8 months (UNEP Working Group for Cleaner Production, 2004a). Similarly valuable organic by-products such as phenolic antioxidants from marc, bioflavours from vegetable residues, fish oil, citrus oils, chitin and chitosan, enzymes such as bromelain can also be extracted from food waste and utilised by other industries such as food processors, livestock and fish processors, pet food manufacturers, renderers and many cosmetic and biomedical manufacturers. An innovative solution was found by the Original Juice Company who was able to reduce its disposal costs from $40 000 a month to a mere $3000 a month through the sale of its orange peel waste. Pressed orange peel is sold for cattle feed, along with juice from the peel which is converted into molasses. A citrus oil recovery system produces d-limonene, a natural petrochemical-free agent used for household cleaning. The company is now generating over $250 000 each year from the sale of recovered products (Food Victoria, 1996, 1998).

Organic wastes, including biosolids (which are the part of the waste stream containing solids after wastewater treatment), can also be rich in nutrients such as nitrogen, phosphorous and potassium and high in organic content. These characteristics can make them a valuable raw material for stock feed and compost, vermicomposting, soil injection and landspreading industries. Murray Goulburn's dairy processing plant in Maffra, recovers separator de-sludge and milk solids retained in the dyer wet scrubbing system for recycling as pig food while its Koroit plant has established a composting facility on its treatment farm for sludge saving $72 000 in disposal costs. The payback period, a mere 6 months (UNEP Working Group for Cleaner Production, 2004). The

DAF (dissolved air flotation) sludge from Dairy Farmers wastewater treatment plant at Lidcombe is collected for direct soil injection on farms west of Sydney. Dairy farmers sees this service as invaluable in periods of drought (UNEP Working Group for Cleaner Production, 2004). .

Creating a market for a new product made from a by-product can change a solid waste problem into a valuable source of revenue and employment. In Australia around 6000 tonnes of recovered PET is exported overseas where it is made into polyester for clothing. Such technology can not only help to reduce waste but in some cases reduces pressure on depleting natural resources. For example, RMIT University in Melbourne has produced a material from waste rice husks, thermoplastic polymer resins and nylon carpet offcuts that could substitute for timber in roadside posts, building panels and spacers for shipping (RMIT, 2003).

Water

Australian food processors consume more water than any other manufacturing group, (around 34% of this group or 180GL per year AATSE, 1999). Some incentives for food processors to reduce water consumption include recognition of the true costs of water (including its purchase cost, heating and cooling, pumping, treatment and final disposal), new charging arrangements by local governments to recover water costs, higher costs associated with operating wastewater treatment plants to meet rising standards or increasing pressure on limited water supplies. Food companies are coming under pressure to find new and novel ways to recover water, reduce their wastewater load and water consumption using greater process control, as well as increasingly finding opportunities to recycle water both on and off site.

Food processors are increasingly using automatic monitoring and process controls to reduce water consumption. In recent years new technology has produced durable nozzle designs that allow for reduced water use without comprising spray effectiveness. Water flow control devices can automatically cut off water supplies and reduce unnecessary consumption and thereby costs. Monitoring devices vary from simple level or flow controls to more complex instrumentation such as pH, conductivity and turbidity. Sensors are being widely used to detect product, chemical and water interfaces. A classic example is in CIP systems where such process controls prevent premature diversion of cleaning streams to drain and allows for the recovery of valuable resources. Pauls Ltd for example, previously utilised a single-use CIP system where all water and chemicals were used once. The system has been replaced with a multi-use CIP system that recycles final rinse water for the pre-rinse cycle. All chemicals used in the system are also returned and circulated through holding vats where temperature and conductivity are monitored and automatically adjusted to meet specific specifications. The new CIP system saved Pauls $40 000 annually with a payback period of only one year (Environment Australia, 2003a).

Some wastewater streams produced by food companies are relatively clean and can often be recycled or reused for processes that do not involve contact with edible product. A number of states throughout Australia have now produced recycling strategies that have amended existing laws to support water recycling and are developing new legislation, especially in regards to the approval process (QEPA, 2004). Food processors, for example, have been able to modify washing equipment to include a recovery tank to store final rinse water for pre-rinsing or reuse process water for other plant operations such as cleaning, cooling or boiler make-up water. Such recycling is becoming increasingly recognised as not only safe and environmentally sustainable but also cost effective. The Smith's Snackfood Company in South Australia was generating wastewater containing 10% solids that was costing $130 000 annually in disposal fees. By introducing new hydrocyclones the company is now able to separate solids so the cleaner water can be collected and recycled. Waste disposal costs have fallen from $144 per tonne to $40 per tonne and the payback period was five weeks (Environment Australia, 2003b). The nutrients contained in some kinds of food processing wastewater may also be a useful resource with innovative options including irrigation for pasture, crops and forestry, land rehabilitation and even aquaculture.

Packaging

Although packaging identifies the product while playing an important role in protecting the product, preventing waste from spoilage and damage, food processors are also increasingly recognising that it not only ultimately produces waste but also consumes valuable resources. Food processors are not alone in their thinking, with public expectation for environmentally responsible packaging also growing along with equally high expectations about packaging performance, convenience and presentation. An Australian Food and Grocery Council survey showed that food and grocery manufacturers identified packaging as being the most significant environmental issue of the last five years (AFGC, 2001). The importance placed on packaging may result from increased awareness as a result of the National Packaging Covenant. Many excellent examples of packaging innovation that balances these environmental considerations with commercial necessities could be discussed in this paper, however space precludes. In an effort to avoid or even eliminate unnecessary packaging companies have sought to change packaging design. Ingham's Chicken for example was able to eliminate the use of over 3 million plastic trays by bagging whole birds in permeable shrink bags (Ingham Enterprises Ptd Ltd, 2003). Many companies now use computer programs to assess the effects of design changes. For example bottle manufacturer Sidel can digitally simulate the mechanical strength of specifically shaped bottles to determine the thickness required while keeping the weight of the bottle to a minimum (Food Technology and Manufacturing, 2001). An excellent example to demonstrate the success of light-weighting is Mrs Crockets Kitchen who replaced 95g plastic tubs with lids for packing salads with 14g cryovac VVP (vertical pouch packaging) packs. The packaging also boosted shelf life and is leak resistant and user friendly (Food and Pack, 2002). The huge interest in recycled and recyclable packaging has found companies seeking to maximise their ability to recycle packaging materials. This has been accompanied with companies stipulating environmental standards from packaging suppliers (supply chain management) and consumers demanding better information on labels and more credibility from eco-labelling schemes. A particularly interesting innovation on the horizon is bio-plastics, where the package is not merely biodegradable, but also made from renewable resources.

Summary

In order to progress to sustainability, food companies will have to find new ways of producing products for continuously more discerning customers, while at the same time reducing costs, paying attention to government regulations and possibly a depleting resource base e.g. threatened water supplies. We believe that eco-efficiency has demonstrated that there are many solutions that are beyond the "low-hanging fruit" classification normally associated with the strategy. There are many additional eco-efficiency activities, such as benchmarking, that we have not been able to discuss here, that are also contributing to a more sustainable future for the food processing industry as the uptake and role of eco-efficiency expands and there is more realisation of its important profit- enhancing role. Companies willing and able to innovate with technology, with tools such as LCA and with supply chain management and other eco-efficiency strategies, companies will be able to find more sustainable and profitable outcomes

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