NON-DAIRY POWDERS IN NEW ZEALAND

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New Zealand Food Innovation Network

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Oct 2016

Table of Contents

EVALUATING THE OPPORTUNITY FOR THE DEVELOPMENT OF NON-DAIRY POWDERS

INTRODUCTION

Global macro trends confirm that consumers are increasingly looking to food for not only basic nutrition, but also to provide additional benefits to support a healthy lifestyle. The functional food and nutraceutical industries are responding to this increasing consumer awareness, of the link between diet and disease and of an aging population by investing in the development of products to meet this market demand. The health ingredient and functional foods industry within NZ is still relatively small compared to international standards, but is predicated to play an increasing role in NZ's future export profile due to the exciting growth potential. New Zealand's isolated location provides optimal conditions for producing a wide range of high quality ingredients and natural products that are based on a safe and reliable source.

This project seeks to establish a commercial understanding of New Zealand's ability to service this market opportunity through creation of high value powdered products. We are specifically focusing on exploring materials that are in the non-dairy sector. This project has investigated the gap between New Zealand's primary products industry and the capability required to exploit/address these export opportunities for NZ Food & Beverage (F&B) companies. The report has focused on three fundamental areas; (1) Raw materials within New Zealand, (2) Technology Stretch and (3) Commercial Opportunities.

The hypothesis being assessed is that there are opportunities in the added value food & nutritional products space that are largely untapped and that access to appropriate, scalable drying technologies has emerged as a barrier for companies to explore these opportunities further. This report has taken a systematic approach to the unstructured and anecdotal feedback around the need for non-dairy drying capabilities. The approach is to validate that there is a market demand and then identify feasible technological solutions to meet these needs.

ACKNOWLEDGEMENTS

This report was initiated by the New Zealand Food Innovation Network (NZFIN) and supported from our partners Bioprocessing Alliance (BPA), Callaghan Innovation and AgResearch.

Without input from our research partners, this report would not have achieved our objectives. In particular, we would like to thank Paul Rose, Stephen Tallon, Aden Fareh, Brendan Haigh and their associated team members. We would like to express our gratitude to AGMARDT for their financial contribution to enable independent project managers the time to comprehensively evaluate the market opportunities and technical aspects of this project.

Furthermore, we thank those individuals and companies whom supplied vital market information with the vision to establish new drying capability within the New Zealand industry.

Project Mangers / Publishers

Sally Gallagher & Shane Kells

Product streams or bio resources explored were classified as:

- Fruit - High Brix
- Fruit & Vegetables - Low Brix/High Fibre
- Meat, Blood Proteins & Hydrolysates
- Honey (high brix)
- Seafood & by-products

Spray drying and freeze drying are well understood with bench scale and pilot scale capability accessible, combined with available expertise. The potential adoption of new drying technologies was considered, i.e. those that are, and not currently available within NZ. It was determined that for any of these to be fully assessed from a business case perspective, or in terms of new product development, it would be advisable to create access to pilot scale plants for process simulation and prototyping of products. It was suggested that the pilot scale plant should ideally be compliant allowing food grade product samples to be sent to market. There are a variety of pilot plants that can be accessed around the country. Callaghan Innovation can also offer engineering capability toward technology transfer from small scale to commercial manufacturing scale.

BPA Virtual Pilot Plant Database for further processing options: https://vppn.bioresourceprocessing.

THE EXPORT OPPORTUNITY

New Zealand has a proven track record with respect to exporting high quality whole and processed foods based on a strong primary products base and history. The Coriolis Report (Investors Guide to NZ F&B Industry, Nov2015) shows that F&B products contributed $30.7 billion export revenue in 2014 which is nearly half of NZ's total export value ($66.2b). While this is an impressive statistic there is a major opportunity for NZ to be a global F&B exporter with significant untapped potential, particularly in the added value processed food space.

New Zealand is a young country still discovering its comparative advantages and new industries continue to emerge. In the past twenty years, New Zealand wine, honey, aquaculture and avocados have all emerged from almost nothing into world leading sectors. In summary, New Zealand has a strong primary F&B core, with a range of emerging growth categories.

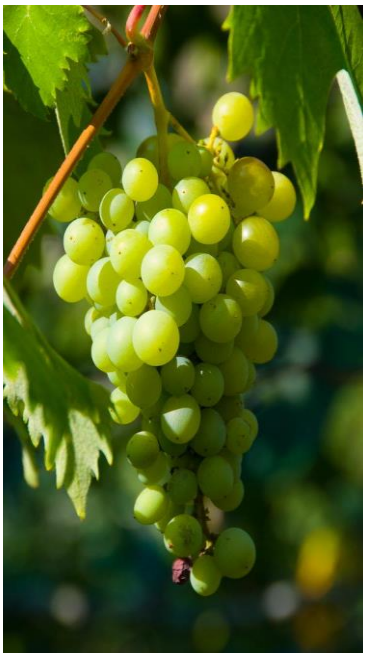
"Naturally Functional" is one of the biggest food and nutrition trends being seen in western markets and this is now developing across many Asian markets. This trend overlaps & strongly influences most other food and nutrition trends. The naturally functional proposition is being used to create new brands and new categories. Consumers are seeking products with a "health halo" e.g. coconut water, blueberries, but also, they want the naturalness. Consumers are drawing their own conclusions based on positive media attention to foods with natural or intrinsic health benefits

The New Zealand F&B processing industry is well poised to take advantage of these macro market trends. (Food, Nutrition & Health Trends, J. Melletin, 2015).

Consumers are increasingly looking to food for not only basic nutrition, but also to provide additional benefits to support a healthy lifestyle. Functional food and nutraceutical industries are responding to increased consumer awareness, by linking diet, disease and aging population, subsequently investing in the development of products to meet this market demand. The health ingredient and functional foods industry within NZ is still relatively small compared to international standards, but is predicated to play an increasing role in New Zealand's future export profile, due to the exciting growth potential. New Zealand's isolated location provides optimal conditions for producing a wide range of world class ingredients and natural products based on a safe, reliable and high quality source. Data outlining the value for specific food groups are tabled below.

Ref: Coriolis Report & MBIE statistics (15Feb2016)

TABLE 1 - TOTAL FOOD PRODUCT EXPORTS FROM NEW ZEALAND (2015)



Food Product	Quantity ('000kg)	Value (NZ$ m)	3 year CAGR
Avocados	26,933	99	10.9%
Berries	3,286	33.9	19.4%
Cherries	3,047	23	33.1%
Honey	9,272	168	6.4%
Peas	50,745	86.3	0.2%
Shelled Beans	23,945	35	6.4%
Fish (Total)	450,000	665	2.0%
Salmon	941	21	0.06%
Vegetables	6,163	327	3.0%
Apples	3,841	425	3.0%
Kiwifruit	570	833	5.0%
Emerging Fruits/Nuts	160,000	160	15.0%
Seafood -mussels	83,561	204	9.0%
Blood Products	Unknown	11,025	Unknown

Functional foods or health ingredients can be categorised in three ways:

- Products that are inherently healthy
- Products that add a bioactive compound to provide a health benefit
- Engineered functional foods that deliver a desired benefit

It is believed that New Zealand's wide variety raw materials selection enables companies to be active in all three categories. Producers, food manufacturers and exporters can build on this strong export base by creating foods that meet growing demand for health ingredients and functional foods.

The Products, By-Product Streams or Bio-resources

Based on the collective knowledge of the project team, a list of bio resources or product streams were identified as being representative of the challenges identified within the scope of the project. Resource streams were classified into the following categories. They were expected to deliver challenges in terms of either drying requirements, either from a technical and/or regulatory perspective.

- Meat & blood proteins and Hydrolysates
- Fruit – high Brix
- Fruit & veg – low Brix, high fibre
- Honey (high Brix)
- Seafood proteins and Hydrolysates (*)
- Forestry (aqueous extracts) (*)

(*) These streams although identified in initial discussions were not explored in any depth within the scope of this report, particularly in terms of market intelligence due to a lack of specific company feedback.

Horticultural Industry

It is anticipated that a significant opportunity exists to extract value from raw materials within the NZ Horticultural industry. The NZ horticultural industry contributed $2.3b in 2005 in export revenue, growing to $4.2b by 2015. This growth has come from the export of high quality fresh produce and processed fruit which in terms of volume, is largely in the form of wine. The other key crops contributing to this growth are kiwifruit and apples.

The market analysis completed has focused on core crops with sufficient volume. This enables the products generated to be developed at a scale, sufficient to service export volume opportunities. The crops that have been explored as part of the horticultural sector were supported by the statistics outlined in Table 1 below - i.e. Grapes, Kiwifruit, Apples and Avocado. The contribution from fresh and processed vegetable crops is not as significant however should not be discounted; only the data set for fresh & processed fruits are provided below.

For more comprehensive data on NZ's horticultural industry visit: http://www.freshfacts.co.nz/files/freshfacts

Table 2 - Horticultural Growing Statistics - Fresh & Processed Fruit Products

Horticultural exports, year ended June ($ million, fob)	1985a	1995b	2005b	2010b	2014b	2015b
Fresh Fruit						
Apples	108.2	343.6	387.0	324.6	536.4	561.8
Kiwifruit	171.9	320.8	720.2	995.7	930.5	1,181.9
Avocados	n/a	n/a	29.0	59.9	93.0	115.5
Other Fresh Fruit (includes berries)	28.4	57.6	51.5	74.7	96.4	122.9
Total Fresh Fruit	308.5	722.0	1,187.7	1,454.9	1656.3	1,982.1
Processed Fruit						
Wine	3.0	42.0	432.7	1,036.8	1,321.4	1,406.2
Fruit Juices	9.6	30.5	34.5	31.7	54.6	46.5
Jams	n/a	n/a	18.1	48.4	25.8	29.9
Processed Fruit (other)	40.3	44.3	49.2	75.1	91.0	84.7
Total Processed Fruit	52.9	116.8	534.5	1,192.0	1492.8	1,567.3
Horticultural Exports as % of NZ merchandise exports	4.4	7.0	7.5	8.3	7.6	8.8

(a) Bollard (1996) and (b) Statistics New Zealand *Estimate Source: For the full data set including vegetable growing statistics, refer to freshfacts.co.nz

Grapes

The USA, UK and Australia accounted for 76% of New Zealand wine exports by value in 2015, with exports between $350m and $370m (FOB) for each. Despite the decline of grapes volume for wine between 2011 and 2015 (from 4.45m MT to 3.3m MT) the volume of by-product that results are still substantial. This by product is of real interest to the industry and provides an opportunity to add value due to the components contained in the resulting material, particularly the red skins.

Grape seed extract/powder is a product that can be developed from this by-product stream. This type of product is currently selling on line for US $5/100g and is largely valued by the “active components”, the oligomeric proanthocyanidin complexes (OPCs) that are contained in this material. OPCs are known for their antioxidant activity and there are published studies claiming that these complexes have other potentially beneficial activities, e.g. antibacterial, antiviral, and anti-inflammatory. Based on reported findings, OPCs may be a useful component for inclusion in products that are seeking to make claims, however companies need to show activity in their final product and provide research to substantiate such claims.

Powdered products created from grape skins are known for their polyphenol content. Polyphenols are antioxidants from plant foods that work in the body to enhance health and although their specific properties are still being researched it is often stated that they can reduce the risk factors and protect the body against many types of chronic diseases. The current average price point for grape skin powders NZ $40 /kg upwards.

Discussions with a Hawke’s Bay based winery has verified the opportunity exists and that powder can be readily created via freeze drying. Defining the market potential and commercial model is the current challenge for many of these types of opportunities.

Table 3- Production Volumes 2010 – 2015

Variety	Production area (ha) 2010	Production area (ha) 2015	Production (tones) 2010	Production (tones) 2015
Sauvignon blanc 16	16,910	20,266	174,247	216,078
Pinot noir	4,773	5,564	23,655	25,763
Chardonnay	3,865	3,361	26,322	27,015
Pinot gris	1,763	2,456	12,810	19,707
Merlot	1,371	1,320	8,885	9,397
Riesling	986	777	5,416	4,535
Gewürztraminer	314	367	1,556	1,761
Syrah	297	435	2,112	1,497
Cabernet Sauvignon	519	300	2,203	1,376
Muscat varieties	125	37	793	301
Other white vinifera	382	120	3,194	2,935
Other red vinifera	392	291	2,382	2,022
Unknown & hybrids/other	1,731	565	2,425	13,613
TOTAL	33,428	35,859	266,000	326,000

Table 4- Regional Growth Trends 2010 – 2015

Variety	Production area (ha) 2010	Production area (ha) 2015	Production (tones) 2010	Production (tones) 2015
Auckland / Northland	16,910	20,266	174,247	216,078
Waikato / Bay of Plenty	4,773	5,564	23,655	25,763
Gisborne	3,865	3,361	26,322	27,015
Hawke's Bay	1,763	2,456	12,810	19,707
Wairarapa	1,371	1,320	8,885	9,397
Marlborough	986	777	5,416	4,535
Nelson	314	367	1,556	1,761
Canterbury / Waipara	297	435	2,112	1,497
Otago	519	300	2,203	1,376
Other / Unknown	125	37	793	301
TOTAL	33,428	35,859	266,000	326,000

National Science Challenge

There is a National Science Challenge operating in New Zealand, called the High Value Nutrition programme which has been established to support companies in scientific study. The aim is to provide High-Value Nutrition by harnessing New Zealand's world-class scientific expertise. This intern creates market and industry relevant knowledge which aims to deliver a competitive advantage to New Zealand's food and beverage exports. For those looking for assistance Visit:

http://www.highvaluenutrition.co.nz

Avocados

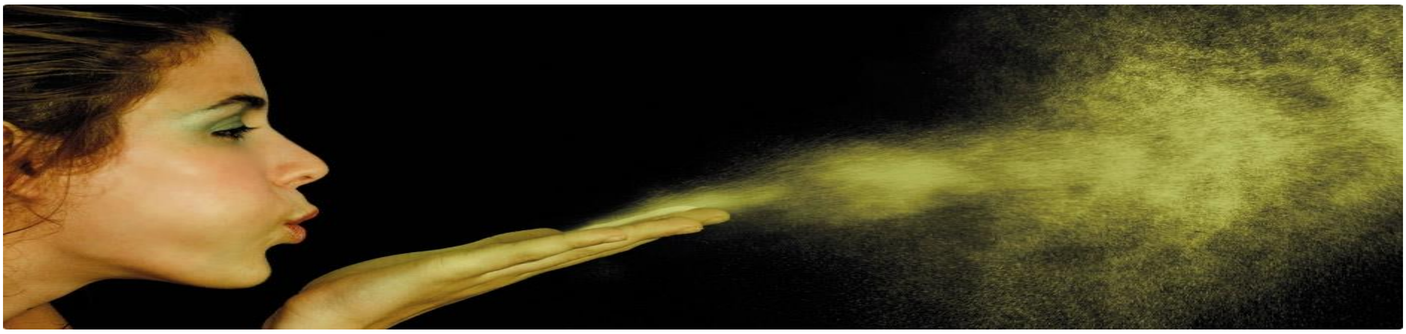
Avocados are a good source of pantothenic acid (vitamin B5), vitamin K and fibre, which aids digestion and helps maintain regularity. Avocados naturally are high in magnesium, phosphorus, iron and potassium, containing even more potassium per gram than bananas. A seven-year study published in Nutrition Journal (2013) found that avocados were associated with a reduced risk of metabolic syndrome, which refers to a group of symptoms shown to increase the risk of stroke, coronary artery disease and diabetes.

Avocado industry profile

New Zealand has approximately 1,700 growers with a total planted area of 3,661 hectares. The Bay of Plenty is New Zealand's main avocado growing area with around 68% of New Zealand's planted hectares. Whangarei and the Far North are the other significant growing areas with approximately 18% and 10% of plantings respectively. The Hass variety is harvested for export from late August through to late March. About 80% of export grade fruit goes to the Australian market with the balance going to Japan, Singapore, Thailand and Korea, and ten other smaller markets. (Data: New Zealand Horticulture Export Authority, ending June 2014) For those seeking further information refer to: The Avocado Growers' Association and Avocado Industry Council (www.nzavocado.co.nz)

Adding Value

In the past, FoodWaikato have undertaken spay drying of the avocado pulp for Tauranga based company Avocado Oil NZ. The aim was to add value to the by-product coming from the avocado oil production turning pulp to powder. FoodWaikato were successful in commercially spray dried avocado powder which was believed to be the first pure spray dried avocado powder, no carries were used. Predominately the method used to achieve a powder form is through freeze drying, however the cost is approximately three times that of spay drying.



Open market analysis of Avocado powder currently sells on line between US$5 -$90/kg. The end use for this material is largely unknown however it is believed to be an intermediate ingredient utilised in a health food product.

Kiwi Fruit

The 2015/16 kiwifruit season broke records for the industry and Zespri with the biggest-ever total return to growers, highest-ever Green return per hectare and record sales volumes for both Zespri Green and Zespri SunGold Kiwifruit.

Zespri total sales revenue for the season also grew to $1.9 billion, up 21 percent from the previous season. The total fruit and service payment to growers for New Zealand-grown fruit increased 22 percent on the previous year to $1.143 billion, with average return per hectare reaching a record $60,758.

“Zespri sold 131.6 million trays in the 2015/16 season, up 21 percent on the previous season. New Zealand-grown kiwifruit sales hit 117 million trays – nearly 22 million trays more than the previous year – and 14.5 million trays of non-New Zealand kiwifruit. (Data: http://www.zespri.com)

PSA tolerance

Since this peak, volumes and value of exports had declined by $115m over 2013 and 2014 because of lost production due to Psa.   SunGold's PSA tolerance combined with its commercial qualities made it the cornerstone of the recovery pathway from PSA and this sweet, juicy fruit has become the engine driving the industry’s future growth. There are 4,800 hectares of SunGold planted in New Zealand and Zespri have reported they will release a further 400 hectares of SunGold in 2016 and potentially another 400 hectares a year for 2017, 2018 and 2019. This decision has been made in response to overwhelming demand from customers and consumers around the world. The orchard gate returns have grown exponentially over the last decade and based on a worldwide appeal and demand continue to grow (refer Table 3 below). (Data: freshfacts.co.nz/files/freshfacts)

By-Product Opportunities

Yield is often impacted by climatic conditions and in 2003 crops were reduced 20-30% by spring frost damage. Pollination can be varied due to weather conditions, while wet conditions in autumn may also reduce fruit size. The growers are paid by the fruit size and therefore are motivated to grow larger size fruit with corresponding on-orchard practises targeting these outcomes. To achieve these growers must thin small and odd shaped fruit from vines, which most are discarded as unripe fruit. Furthermore, the pack house grading provides an opportunity to utilize kiwifruit into added value product when not achieving dry matter, shape or size for export markets.

Table 5 - Gold Kiwi Fruit Postharvest Statistics & Returns

Season (ends 31 March) Crop volumes (million)	2000	2005	2010	2014	2015
Trays sold	51.8	79.7	96.5	86.1	95.2
General Statistics					
Yield (trays/ha)	5,295	7,847	8,546	8,023	8,706
Area planted# (ha)	10,234	10,934	12,525	10,944	11,233
Growers/suppliers (no)	2,681	2,760	2,711	2,350	2,540
Pack houses (no)	118	88	71	54	50
Cool stores (no)	106	89	77	68	62
Orchard Gate Return ($/ha)	15,366	34,738	39,142	51,153	57,369

Kiwi Fruit Health Claims

Many health claims are associated with kiwi fruit and range from benefits in terms of lowering your risk for blood clots and reducing the amount of fats (triglycerides) in your blood, ultimately providing support for cardiovascular health. Protection against macular degeneration and an excellent source of vitamin C (a water-soluble antioxidant in the body that can act to neutralise free radicals) are other emerging health propositions. Substantiated health claims are a future opportunity for the industry, particularly leveraging of current substantiated health claims around the benefits of green kiwifruit in the digestive health area. Green kiwifruit provides a strong positioning for functional food and nutraceutical product areas.

Apples

In the past decade, the two largest volume apple varieties ‘Braeburn’ and ‘Royal Gala’ have reduced from a combined 55% of planted area in 2006 to 42% in 2015. ‘Braeburn’, a New Zealand-origin variety freely grown in many countries, had a planted area in New Zealand of 2,464 ha in 2006 but reduced to 1,352 ha in 2015. Many of the larger vertically integrated pip fruit players are looking to invest in higher value proprietary varieties, e.g. Jazz, Envy.

Table 6 - Apple Statistics

Season (ends 31 Dec) Crop volumes (000 tones)	2010	2011	2012	2013	2014	2015
National Export Production	260	300	285	320	311	331
Growing method: IFP	94%	94%	96%	95%	94%	94%
Certified organic	6%	6%	4%	5%	6%	6%
General Statistics						
Export FOB $/TCE	$22.93	$21.79	$23.04	27.69	$29.64	$32.83
Area planted# (ha)	8,630	8,4070	8,324	8,372	8,429	8,566
Export Orchards (no)	985	976	953	953	921	919
Pack houses (no)	62	70	65	61	56	56
No of Exporters	95	90	88	84	76	79
Integrated Fruit Production sustainability; TCE: tray equivalents 18 kg sale weight. Source: Pip fruit New Zealand						

In 2015, New Zealand exported apples to the value of NZ $561m FOB to 65 countries. Nine countries imported an average of $45m each, with 43% (NZ $241m) being sold in Asian countries. The Asian region provides a huge growth market for the NZ pip fruit industry and the trend is that NZ varieties are being well received in these markets. (freshfacts.co.nz)

By-Product Opportunities

The substantial volume of apple production generates a significant volume of second/third grade material that cannot be sold as premiium fresh fruit. This means that a substantial volume of the total NZ crop is sent for bulk juicing. This in itself provides opportunities for exploring the bulk material, but also through the juicing process there is a significant volume of pomace material generated. It is this material (as with grapes), that provides an opportunity for the industry if this material can be stabilised and then dried into a format that meets a gap in the market. Apple pomas is a good source of fibre and potentially contains a series of polyphenol materials, which may have associated antioxidant benefits for functional food ingredients or consumer products.

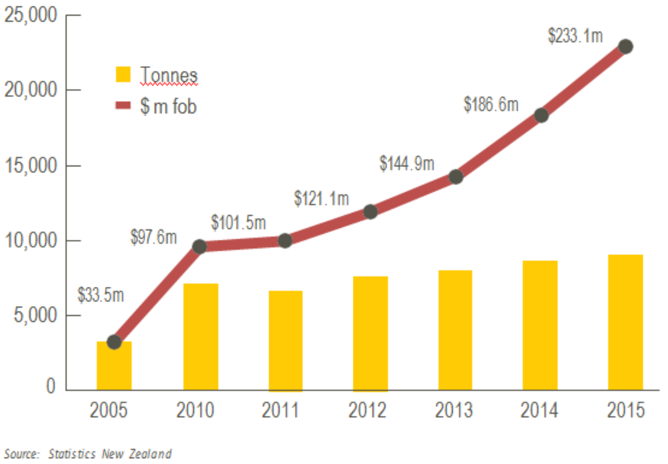
The key challenges for the industry are the ability to stabilise this highly fermentable material and then apply appropriate processing. Linking the material to a market opportunity continues to be a major hurdle for many of this primary based companies. Although these companies are active in export markets, their focus is generally fresh and so they lack the in-house expertise in FMCG or functional food/supplement sectors. This is the same trend seen with the grape skins that are the by-product of the wine making process as discussed above.

Honey

Honey production within New Zealand has grown to 19.7m MT in 2015. The value of New Zealand’s honey exports shows a corresponding increase in value to $233.1m in 2015 (2014: $186.6m). The major export markets exceeding FOB $20m in value are: United Kingdom $45.2m (2014 $39.3m), Australia $33.1m ($26.4m), Hong Kong $28.0m ($26.4m) and China $21.5m ($15.4m). Global demand for natural honey is growing and highlighted by the fact that this product was also exported from New Zealand to an additional 46 markets.

Another promising trend is the increased volume of natural honey that is being exported in an added value format. It has been estimated that in 2015, 46% (9,046 tonnes) of NZ natural honey production was exported and of this volume 86% by weight was in retail packs.

Table 7- New Zealand Natural Honey Exports (2005 - 2015)



Honey powder enquiries through FoodWaikato have remained consistent over the past few years, unfortunately FoodWaikato are not in the position to dry the product. The principle of spray drying into a fine powder is reasonable simple if adding fructose as a carrier e.g. Maltodextrin will enable free flowing powder. Honey powder is extremely hygroscopic in nature and absorbs moisture during packaging and transit, particularly under humid storage conditions or when left in open containers. These are some of the challenges that need to be overcome to fully explore this opportunity and leverage growing popularity of honey powders. G & S Foods are based in Canvastown at the top of the South Island of New Zealand and have a unique technology for drying honey. Although this report has not covered the business activities they should be recognized as experienced in honey drying. For those considering this process visit: http://www.gsfoods.co.nz for more details.

Product Opportunities

Applications for honey powder include creams, cosmetics and pharmaceutical products and therefore the price point can vary. Much of the interest is the application of honey powders include antiseptic and antibacterial properties. The application of heat during the drying process should be considered, high heat may be detrimental to natural antibacterial properties. Honey varieties will change consistency of sensory elements, colour, aroma and flavour. Honey powder can absorb moisture when exposed to air, careful planning of the packing process after drying will be critical to the consumer’s experience.

The Meat Industry

The potential for the extraction of bioactive compounds that can be isolated from meat co -products is relativity new for New Zealand, practically in terms of being done at any scale and targeting export markets. Product safety and traceability are a key consumer drive, with the ability for companies to provide traceability from the farm to plate being essential for a growing number of consumer groups. New Zealand's BSE-free reputation provides an opportunity to leverage meat based powder.

Products & Dynamics

The present yield as a carcass is only 34% with the remaining 66% being classed as by-products. The ability for New Zealand meat based companies to compete in the lucrative lipids, enzymes and protein market has been hampered by the lack of New Zealand owned processing facilities. If the appropriate processing capability was available at a commercial scale, then there is the potential for products to be manufactured to target the nutraceutical and pharmaceutical markets. Understanding the market opportunities is a gap for many players and requires investment for these opportunities to be realized.

Proliant opened a blood plasma manufacturing plant in Manawatu in 2016. The privately-owned company takes blood from cattle and makes it into products such as diagnostic test kits and vaccines for research and in drug production. Proliant operates 60 plants worldwide, with annual revenues of about US $1 billion. Proliant has shown New Zealand's meat industry how to successfully add value to a waste or by-product steam, with estimated processing capability reported to be 3000 MT/annum.

To understand further potential for the NZ meat industry, it is important to review the products that are currently available. The data represented in Table 8 provides the components from which the current extracted meat and co-products per animal. Table 5 shows the bioactive components from which functional or nutraceutical products could be developed. This data emphasizes the opportunity for the meat industry to further develop a bioactive market from by-product streams available within the industry.

Table 8 - Proportional Value from Meat and other Co-products

Product	Cattle (%)	Pig (%)	Lamb (%)
Carcass meat	34	52	32
Bones	16	17	18
Organs	16	7	10
Skin & Attached Fat	6	6	15
Blood	3	3	4
Fatty Tissue	4	3	3
Horns, Hoofs, Feet, Skull	5	6	7
Abdominal, Intestinal Contents	16	6	11

(Reference: Food and Agriculture Organization of the United Nations (FAO 1998)

Bioactives

The bioactive components listed, highlight the opportunity for creation of materials containing potential health promoting properties. This data is representative of what is available and not considered an exhaustive list.

Table 9 - Bioactive Components Summary

Source	Bioactive Material	Bioactive Concentration
Brain	Phospholipids	2.1g/100g
Blood Plasma	Tranglutaminase	4g/tonne
	Fibronectin	300ug/ml
	Immunoglobulin	13mg/ml
Cartilage	Chondroitin Sulphate	2% of dry Wt
Heart	Carnitine	19mg/100g
	Carnosine	23mg/100g
	Lipoic acid	1.0mg/100g
	Phospholipids	0.8g/100g
Kidney	Carnitine	2mg/100g
	Lipoic acid	1.3mg/kg
	Phospholipids	1.1g/100g
Liver	Phospholipids	1.5g/100g
	Carnitine	3mg/100g
	Lipoic acid	1.1mg/kg
Lung	Glycosaminoglycans	5g/50kg
Muscle	Glutathione	20mg/100g
	Carnosine	0.3g/100g
	Anserine	52mg/100g
	Carnitine	62mg/10g
Pituitary Gland	Andrenocorticotrophic	0.75g/454g
Spleen	Phospholipids	1.1g/100g

Pharmaceuticals

The biggest change in by-product usage has occurred within pharmaceutical applications. The primary bovine tissues used in applications relating to human therapy are the pituitary gland, heart, pancreas, and intestinal mucosa. A significant market that continues to expand is using beef by-products via research in cell media, blood,

peptides, enzymes etc. The adrenal gland, thyroid, parathyroid, ovaries, brain, spinal cord, spleen and eyes also have significant application in the research arena.

The compounds that are of interest to the pharmaceutical industry and which can be isolated from this meat based materials include:

- endorphins and B-lipotropin fragments
- gastrointestinal peptides and growth hormone releasing peptides

- opioid peptides
- parathyroid hormone and fragments
- corticotropin releasing hormone
- endothelins
- insulin
- thyrocalcitonin

The cosmetic industry is another market opportunity for the use of beef by-products and Table 10 below provides insight into the wide variety of areas where current products are being applied.

Table 10 - Current Applications for Beef By-products as Cosmetic Ingredients

Component	Application
Tissue Extract	(Epiderm Oil R) - made from thymus, placenta & udder. Used in moisturizers and cosmetic creams
Aorta Extract	"Anti-aging" products.
Arachidonic Acid	Isolated from the liver for use as a surfactant and emulsifying agent in skin creams and lotions.
Bile Salts	powerful cleansing agents
Casein	bovine milk protein used in protective creams and as the "protein" in thickening hair preparations
Cholesterol	Emulsifiers and lubricant in brilliant hair dressings, eye creams and shampoos.
Collagen	Used to fill out acne scars, wrinkles and other depressions via injection under the skin.
Collagen Amino Acids	Used in moisturizers, emollients.
Fatty Acids	Bubble baths, lipsticks, soap, detergents.
Gelatin	Protein shampoos, face masks, fingernail strengthener.
Glycerin	Cream rouges, face packs and masks, freckle lotions, hand creams, hair lacquers, liquid face powder, mouthwashes, skin fresheners, and protective creams.
Heparin Salts	Used to prevent lumping of cosmetics.
Hyaluronic Acid	Protein found in umbilicus and joint fluid used as cosmetic oil.
Hydrogenated Fatty Oils	Used in baby creams and lipsticks.
Hydrogenated Tallow	Used as a binder in cosmetics.
Hydrolyzed Collagen	Widely used in a variety of products.
Hydrolyzed Elastin	Used in "youth" creams.
Hydrolyzed Protein	Used to improve combing ease.
Oleic Acid	soaps, cold cremes, shave creams & lotions, shampoos, liquid rouge & make up
Palmitic Acid, Tallow	Texturizer in shampoos, shaving creams and soaps.
Stearic Acid	Deodorants & antiperspirants, foundation, hand, shaving crèmes and lotions, soaps and lubricants. A large percentage of cosmetic cremes contain this ingredient.
Thymus Extract Udder & Umbilical Extract	skin crèmes, moisturizers

Market Opportunities & Market Assessment

The project manager's intent was to complete a market assessment focusing on three specific product streams as listed below. The time to interview companies across all areas would have extended the project timeline considerably and was not considered realistic. Furthermore, information at times had been limited as companies rightly protected IP. It is believing that the feedback that was gathered provided a good representation of the challenges seen across the wider F&B industry. The high-level challenges faced by an organisation within one these areas will be indicative of the hurdles that will be seen across other product areas.

- Fruit & Honey - High Brix
- Fruit & Vegetables - Low Brix/High Fibre
- Meat & Blood Proteins & Hydrolysates

Within these categories, the raw materials that were selected and explored in more detail, were those that contributed to current export volumes. They may also show export growth potential or where a company has been proactive in approaching NZFIN in the past. Scale at an individual company or industry level is important, as there needs to be the capability to consider investment in capital and infrastructure. A significant volume of material is generally required to ensure opportunities are commercially viable. However, the technical solutions in this paper will cover options for the small-scale operators.

A broad range of industry representatives throughout the value chain have been engaged to obtain information relating to potential market opportunities. To ensure intellectual property remains confidential, individual company details have been removed from this report.

This assessment has led to a more in depth understanding of the culture and resulting behaviours of many F&B companies and their approach towards the launch of added value dried products. To complete this market assessment interviews were undertaken with a group of target companies.

A range of standard questions were developed to frame the discussions that were broad enough to alleviate confidentiality concerns for companies, while still allowing relevant information to be extracted.

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The aim of this project is to provide sectors within the F&B industry with sufficient information to enable to them to make informed decisions about the opportunity that exists for non-dairy drying technologies. This report does not attempt to provide any recommendations around a specific location for any processing capability and raw material combination.

Market Conclusions

The companies interviewed have been summarised below and grouped into categories based on their current activity and perceived interest level. From those active in this space through to those who are not even aware that an opportunity exists. This is particularly relevant for those managing a by-product stream which is currently viewed as a "disposal exercise" - rather than an opportunity to add value. This shows the diversity of the companies operating within this industry sector which adds complexity, but also highlights the untapped opportunities.

A major theme that came through from those companies processing fruits & vegetables, particularly those not actively engaged in this space, was that although the technology selection was a challenge, it was the understanding of the potential market opportunity that is a far greater hurdle. ***(MUST BE MARKET LEAD)***

Companies expressed an interest in identifying ways to add value to their high sugar/high fibre by-product stream (pomace) to counter the ongoing disposal challenge this provides. The flip side to a company's growth is that the by-product volume continues to grow in parallel. The challenge is adding value to these secondary streams which are not seen as core to the business and so not instrumental to the company's strategic plan. As such they often have no allocated resources to complete the feasibility required to validate the opportunity - or not.

The quote below, unprompted by a HB winery summarises the general feeling across many primary industry players interviewed:

"Technically a freeze dried grape skin is relatively simple, just expensive.................the market opportunity is the big question?

High cost means it must be a small volume - higher value product. What is this - a food additive? an additive for skin cream/cleaners?

Either way a substantial marketing investment in the international market place is required - unless it is sold to large brand name who then takes all the margin?

SUMMARY OF COMPANIES INTERVIEWED

The feedback and data collated from the company interviews are summarised below:

Product

Interview Comments, Application & Current Activity

Kiwifruit

Apple

Health supplements focus, currently active in this space. Historically using freeze drying but this technology too expensive and have been exploring alternatives as part of their own R&D programmes. They are interested in identifying and investing in a technology that provides a cost competitive position and superior product properties. Trials are underway however the right drying technology has yet to be fully understood.

Kiwifruit

Snack foods - currently air drying kiwifruit via a batch process to produce a range of kiwifruit based snacks. The company has invested in considerable R&D over the past 5 years and will continue to do so. Not interested in accessing dual facility due to confidentially concerns

Indirect feedback is that kiwifruit industry players, particularly pack houses are exploring alternatives for second grade material as this is currently not been capitalised. Struggling against cheap imported materials, difficult to get traction. Would a more cost effective technology option be beneficial?

Exploring a full range of target applications - stock feed, pet food through to human grade food and supplement applications.

Apple

Apple pomace (10,000-15,000MT/annum) is a large and growing challenge as tree plantings are forecast to increase as fresh apple market grows. Immediate challenges to clean up and stabilize material to prevent rapid fermentation are the focus. A natural fibre source - varied market opportunities, with a focus area yet to be identified.

Clarity over market opportunity is a gap preventing commercialization of any R&D completed historically.

Kale & Beetroot

High value food ingredients, powdered vegetables, health supplements targeting food service & domestic use. A recent installation of OVDMA technology for production of beetroot & kale has been undertaken, long term viability of the technology has yet to be fully validated.

Corn, Squash

Large processor of corn & squash. Actively investing in R&D, involved in Bioprocessing Alliance waste stream initiative. Exploring freeze drying with product concept work underway. Marginal in terms of cost of processing - particularly for targeting animal feed products. Potential to explore added value animal feed products. Freeze Drying or other technologies of interest for commercial ingredient opportunities

Corn & Beetroot, Lettuce

Process a large volume and variety of fruits & vegetables, waste streams are wide and varied. Volumes of salad waste - 5-6MT per day, 6-10MT broccoli (potential to freeze), out of size beetroot & melons. Squash waste set to 3rd party for processing. No work being actively done in this space - of future interest, taking a watching brief currently.

Feijoa

Smaller player, currently actively exploring options for producing whole frozen feijoas as well as slices and dices. Technology challenges. Interested in potential drying opportunities in the future, not currently active in this space.

Lemons & Limes

Smaller citrus players have identified opportunities for a citrus powder for use as ingredient or for food service or consumer use. Spray drying not possible as too much carrier required and freeze drying is too expensive to make the product viable. Missed out on opportunities for citrus powder into chocolate applications because of price point. What other technologies are available?

Grapes (Red)

Completed freeze dried work on red grape skins driven by potential interest in associated health benefits. Technically this is possible even though price to manufacture is expensive. The specific market opportunity is the big question and until this can be answered further R&D is on hold. The other question is what is the business model via which added value can be extracted? What position should the company explore within the value chain?

Entire wine industry generates approximately 100MT of waster pa. Currently use waste for composting which limits the company motivation to explore added value, unless risk of investment is mitigated. In direct feedback is that NZ Extracts & others have attempted work in this area in both red and white grapes. Non-food R&D applications are being explored - Perhaps more can be done?

Craig Armstrong, NZTE took samples to a Functional Food forum in Japan - feedback is that there is some novelty and culinary value around dried red grape skins - however price point versus concentration of assumed active present would require more work.

Tomatoes

A major multinational has large ongoing challenges with large volumes of waste available weekly. Fresh tomato waste at peak, approximately 3-6 MT per week, plus tomato vines/clippings - all going to landfill currently. Smaller tomato grower is actively seeking alternatives for added value for a substantial volume of second grade tomatoes. Can organic waste be converted to energy for covered crops? The challenge is to understand the market opportunity - fresh, dried, juiced or other?

Grains (Brewing)

By-products generated from brewing industry are well documented. There is keen interest to find a solution, but market opportunities are largely unknown. Product streams include yeast & spent malted barley grain, Volume yeast 15,000 litres per week, Grain 100 MT per week.

No R&D on these streams completed to date.

Would be interested in facility if built - and would look at processing "all yeast" and 20% grain initially (market demand dependent).

There would be concerns for processing meat alongside fruit and vegetables in the same plant. Reintroduction of bovine proteins into a bovine feed stream is a known vector for viral particles (example is mad cow's disease). Products produced by others largely for animal feed industry - salmon pallets, blending brewer's grains into other streams for animal feeds

Main challenges are commercial aspects, have explored limited analysis of markets/products - all they really know is in stock feed area.

Any application that would work would be a solution to a massive industry challenge. The implications would be tremendous. Another opportunity is to find a way to achieve storage stability to allow sale of feed during winter months.

meat industry

Feedback from players was difficult to obtain particularly around the interest and capability of blood proteins and extracts. There is a lot of assumed intellectual property in this area which sits with key players. This explains why this information is difficult to extract and share in this type of reporting format. Industry growth may be limited due to a un-collaborative approach.

Sea Food

It is widely recognised that most of New Zealand's major seafood/nutraceutical companies are heavily invested in drying technologies but much of the detail is confidential to industry players. Details are not available in the public domain. And as such seafood industry was not a specific target for interviews during this research project. Some feedback from Plant & Food Research is provided below:

Rotary driers are widely used in the production of fish meal (see FAO publication on the production of fish meal and oil, chapter on drying. http://www.fao.org/docrep/003/x6899e/X6899E04.htm#3.1.8 (Drying)

Freeze drying is widely used for drying Green Shell Mussels (GSM) and other nutraceutical raw materials. Batch freeze drying is slow (therefore high capital $ per tonne of product dried), labour intensive and often requiring dried product to be milled/ground. Freeze drying is perceived to have a low thermal exposure. There is an opportunity to introduce new technology for drying GSM; for example, ENZAQ's modified flash drier is reputed to provide fast, cost effective drying of GSM to provide whole GSM powder. http://www.enzaq.com/Flash+Dry+Process.html. Kilns are used for smoking and drying fish and seafood products and are also being used by the small goods and meat product industry. Indirect feedback is that there is some activity with seafood companies considering drying technologies to go alongside rendering plant solutions; however, discussions are currently on hold.

Fruit Leathers

Currently manufacturing using a batch process. There may be future interest in a continuous process. These discussions have not been part of the interview process in this project.

Avocado

Avocado powder industry development is relatively new. FoodWaikato spray drier access is very limited due to regulatory requirements. There are technical or market knowledge gaps. By-product steams per day can be as much as 9000 kg/day during oil processing. This is too large for a batch drying process - must be continuous process to reduce manufacturing costs. Is the high heat of spray drier the best application for functional properties in powder form?

Onions

Ongoing interest in R&D - particularly around adding value to onions - looked at extracts via some fundamental programmes. This includes exploring drying technologies to dry extracts generated from work. Company is in the process of setting up a new R&D programme that aligns with a revised strategic plan. Discussions ongoing

Olives & Avocado

Olive & avocado pomace are collected over a 3-month period, but are counter seasonal so complementary in processing terms. All waste is currently disposed of via stock feed outlets. Currently processing 1200MT of fruit, 50% is pomace. Also, have avocado stone and seed to handle. No work to date done in drying area, only small scale table top trials. There are pre-processing requirements for both olives and avocado. TVP would be happy to process via a dual facility with other industry players. Key hurdle is identifying the end market use or demand as well as the price point the market can withstand. Key question or rather opportunity is largely a “chicken and egg” scenario. What sort of specification can be developed from available stream OR what sort of product does the market demand? What practical R&D is possible, how hard to achieve technically and at what cost - but to sell into which market?

Olive Leaf Extract & Honey

Encountered problems with access to appropriate drying technologies - of interest for berry, seafood & vegetable industry. Currently have a solution for honey but it is not ideal. Olive leaf extract currently dried in Australia because they are extracting it there and there is no processing capability in NZ. There is a big gap in terms of available drying capability within the NZ industry for a range of raw materials - fruit, vegetable and seafood. Opportunity for NZ to install the equipment required to dry olive leaf extract as are looking to source olive leaf from New Zealand suppliers (TVP) to provide dual supply options as risk mitigation. Research around activity levels ex NZ sourced product required.

Potatoes

Via NZTE Customer Manager, a large potato processor has provided an expression of interest to look at ways to add value to by product streams. At this stage they are not proactively working in this space but remains on their radar. BPA project around the manufacture of potato flour. Drying technology is yet to be identified due to viscosity and cost constraints. Perhaps scraped surface drum drying technology may be a candidate? The potential of this initiative is largely unknown at this stage.

TECHNOLOGY ASSESSMENT

The technologies explored within the scope of this report are those that are currently commercial or in a semi commercial state. This project has not explored blue sky technologies as NZ Food Innovation Network is focused on commercialization and so is interested in technologies that are market ready or close to being so. At a high level and in summary the two key challenges to be addressed are:

(1) Technologies too often too expensive

(2) Technologies can't handle current streams due to physical parameters (or a combination of the above).

A literature review was commissioned to assess published data to provide a comparative evaluation of the current commercial or semi commercial drying technologies for producing non-dairy powders. The Bioprocessing Alliance (BPA) team also completed an analysis around current and future technologies that would be applicable for these non-dairy raw material streams. The key findings from these reviews are summarized at the end of this report.

The commercial technologies included as part of the comparative evaluation were known Drum Drying, Tray Drying, Spray Drying and Freeze Drying. Those technologies included within the scope that were considered semi-commercial included Thin Film Drying (or Refractive Window Drying), Osmotic Vacuum drying (Dried Fresh), Vacuum Microwave Drying (Enwave), Vacuum Freeze Drying, Extrusion Porosification technology and Dehumidifier Tray Drying (Remixol). Flash Drying

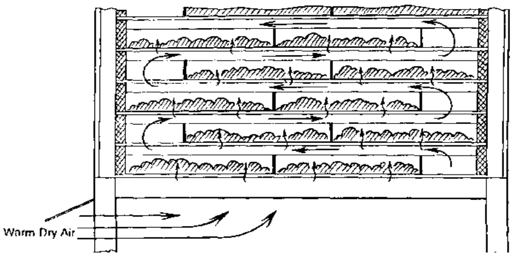
A critical consideration of any technology assessment is to understand the commercial readiness of these alternative technologies. Discussions with potential suppliers have been undertaken as part of this assessment however more detailed discussions would be required for a specific company/raw material compassion to explore the viability of a specific opportunity. The following information will provide the public with a base understanding without getting too technical.

DRYING TECHNOLOGIES

Traditional drying methods include drum drying & air drying which are notorious within the food & beverage industry for producing inferior quality products. Freeze drying and spray drying are known to produce higher quality products and although there is a large volume of knowledge and expertise within the NZ industry, these technologies have their own limitations. Spray drying is limited by the significant capital investment required, which means it is often not commercially viable unless the product can attract premium price positioning. There are also constraints around the type of material that can be processed via spray drying due to viscosity or particulate limitations. Freeze drying is only generally applicable for premium products due to the high costs associated with manufacturing.

Tray Drying

Tray drying (batch process) is also known as forced convection drying or oven drying where the material is spread uniformly on a metal tray. The advantage of tray dryers is that they are simple and less energy intensive, however often shows inconsistency of drying between trays and low energy efficiency.



Schematic representation of typical tray dryer (Geankoplis, Transport processes and separation process principles (includes unit operations), 2003, p. 560)

Although tray driers can accommodate a large variety of products if using high temperature and long cycle times may be unsuitable for many high value or temperature sensitive materials or those prone to oxidation. It is therefore often used for low-value products which can withstand high temperatures. Processing controls can overcome this issue as achieved by a Tauranga company "Drying Solutions" This dryer has very accurate temperature control – depending on the product being dried, temperature range is between 15oC and 60oC, with an aim of ranging from -5oC to 70oC; time adjusted temperature can be programmed (either before or during drying) – e.g. start drying at 30oC and raise it to 40oC part way through and then could reduce the temperature again. The process of drying can be monitored and reported by using a PC.

Drum Drying

Drum drying involves the material being applied as a thin film to the heated surface and the resulting solids then being scraped off. Drum drying can be used for slurries, purees and for heat sensitive products as exposure to high temperatures can be limited. Drum driers produce products with good rehydration properties and can also dehydrate highly viscous foods which are not easily dried via other methods, e.g. pastes and gelatinized or cooked starch. Drum driers generally have high energy efficiency, are easy to operate and maintain and provide flexibility for multiple production runs.

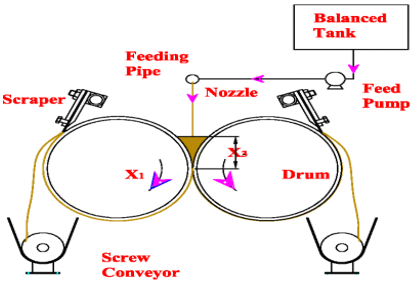


Figure 1: Schematic drawing of a typical drum dryer

With flexibility comes a lower throughput as compared to spray drying and there is also a high cost associated with changing drum surface. There are limitations for use with some materials e.g. high brix fruit products which are not easily scrapped off the drum surface. Other products do not form a good film on drum surface and so are not workable via drum drying. Product scorching, off colour and burnt flavours are common side effects due to direct contact with high temperature drum surface. The drum can be enclosed in a vacuum chamber to reduce the required temperature but adds to the capital investment so only applicable to higher value materials.

Spray Drying

Spray drying is a well-known technology that is used extensively within the New Zealand dairy industry. This process involves dehydrating atomized droplets in a hot-convective medium (air), converting the droplets into fine solid particles. The key advantage of this process is the ability to dehydrate the liquid feed material and to simultaneously transform the material into a particle form. It is used in many applications,

Particularly in the production of instant food and dairy powders. Despite the versatility of spray drying it is restrictive due to the capital investment required. There are also restrictions as the feed is required to have high moisture content to ensure that the feed can be pumped and atomized. The high shear action required during atomization also makes spray drying unsuitable for products sensitive to mechanical damage.

Advantages

- Continuous and easy to control process
- Applicable to both heat- sensitive and heat-resistant materials
- Satisfies aseptic/hygienic drying conditions and dryers of different sizes and capabilities are available
- Different product types: granules, agglomerates , powders can be produced

Disadvantages

- High capital and installation costs and lower thermal efficiency
- Heat degradation possible in high- temperature spray drying
- Processing viscous, fibrous, particulate or high brix materials is challenging.
- High levels of "carrier" material is often required for processing more difficult raw materials, thereby diluting product purity & "naturalness"

Freeze drying

Freeze drying (FD) is based on the fact that frozen water can directly evaporate (sublime) to vapour without going through the liquid phase. In freeze drying, the material to be dried is first frozen, and then the ambient pressure is lowered to permit the sublimation of the frozen water.

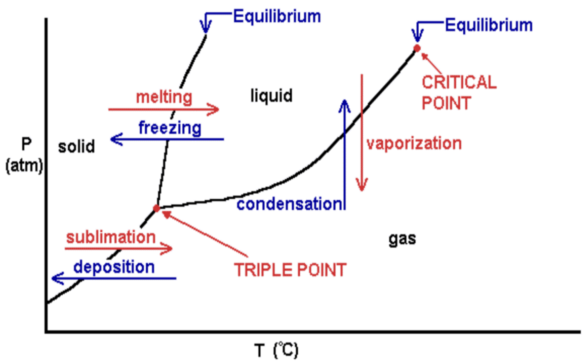


Figure 2: The water phase diagram - Source: http://www.kentchemistry.com/links/Matter/Phasediagram.htm

The fundamental advantage of freeze-drying is that it generates a high quality finished product. The high quality is primarily due to the absence of liquid water and the low temperature required for processing. Product deterioration and microbiological reactions are inhibited, with the primary structure and shape, flavour, colour and texture of the product being preserved. However, despite these advantages there are major disadvantage in terms of the cost per unit to manufacture, where it is recognised as the expensive drying process. On an industrial scale the operating costs are 4-5x higher than spray drying and so are limited to use for high value premium foods. High sugar products can be hydroscopic. Another drawback is the time of drying which can be 1-4 days due to poor internal heat transfer and low working pressures.

Thin Film Belt Drier (previously Refractive Window Drying)

This is a relatively new technology, which is intended for drying heat-sensitive foods, enzymes and pharmaceutical products and is characterized by short time exposure of foods to relatively low temperatures. This novel drying method can convert liquid foods, e.g. purees or juices into powders, flakes, or sheets via short drying times (3–5 min) which results in products with excellent colour, vitamin, and antioxidant retention. These drying systems are simple, operate and relatively inexpensive when compared with freeze drying (FD requires large installations to be economical).

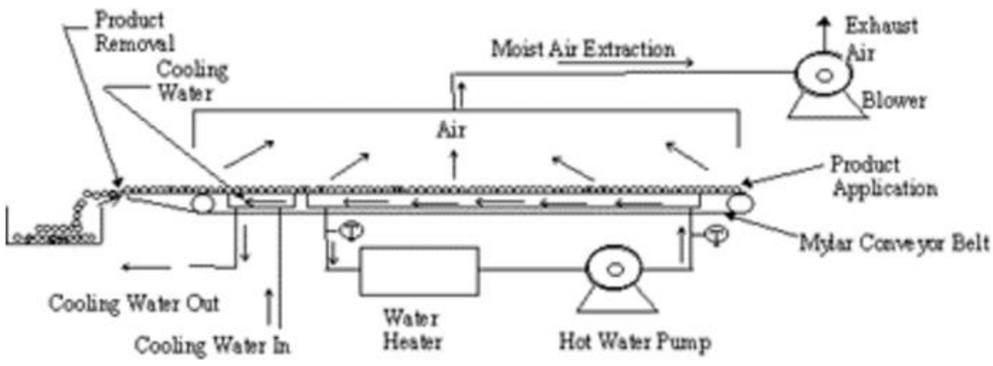
Thin Film Belt drying uses infrared radiation to dehydrate the product, refer *to* below diagram. In this system, the raw material is applied to the drying conveyor belt which is a transparent polymer that floats on the surface of a heated cistern containing circulating hot water (< 100°C). The heat from the hot water is conducted by way of a 'refractance window' through the belt to the raw material. The evaporated moisture is carried away by a fan, and the product is scrapped off and is collected at the end of the conveyor belt. The resulting form is thin flakes, which can be used as-is or ground to powder.

Advantages

- Excellent quality and retention of nutrients colour and flavor
- Mechanical simplicity with modest resources and fabrication providing acceptable throughput
- Cost effective among methods which can also achieve excellent retention of sensory attributes & nutrients
- Diverse energy sources for water heating and process can be significantly less expensive than freeze drying

Disadvantages

- Designed for drying of liquids, may not be applicable for product pieces.
- Modest throughput, with corresponding higher manufacturing costs when compared to traditional higher temperature drying methods such as drum drying or spray drying.



Schematic diagram of a Refractance Window Dryer

Source: http://www.foodonline.com/doc/refractance-window-food-drying-system-deliver-0001

Osmotic Vacuum Drying

Osmotic Vacuum Drying is a modified atmosphere (OVDMA) is a new drying technology developed by Dry Fresh & Scott Technologies Dunedin, New Zealand, which now operates commercially under the Driedfresh™ company name. This technology employs oxygen free, low temperature (<38°C), medium-to-high vacuum processing environment, the technology works as a batch process with a batch size of 150-300kg over 8-24 hours. The system is highly portable. Typical applications include fruit and green leaf drying, specialty ingredients, bulk dried food ingredients. (Driedfresh™, 2016).

OVDMA uses the plant's natural osmotic process to gently remove only moisture without damaging the cell structure of the material.

Advantages

- NZ Company, dryer can be easily transported if required close to crops
- Reasonable operating costs due to energy intensity of thermal drying.
- Osmotic process to gently remove only moisture without damaging the cell structure of the material
- Retains nutrients, flavour, colour, texture and other biologically active constituents."
- Ability to produce infused crunchy snack products

Disadvantages

- Relatively new Technology, different product validation ongoing or yet to be undertaken
- Process control is via the supplier
- Commercial models need to be considered against different products

Vacuum Microwave Drying (Enwave Corp)

The technology works through use of a vacuum in the dryer to facilitate an environment where heating by microwaves can be conducted at low temperatures ~50 ˚C. Drying times vary between 20-60 minutes while drying temperatures were on average between 50 - 60 ˚C with the product surface temperatures around 80 ˚C for 2 – 3 minutes. Examples are n in literature for various plant based foods. Pilot scale units are available and run via a batch process while larger commercial units are continuous processed based (quantaREV). The benefits of this technology are that it uses lower temperatures with shorter run times (1-2 hours to dry) and is also less energy intensive as compared to freeze drying.

This technology is not currently commercially available in NZ. The company that is commercializing the dryer is based in Canada and is still seeking an Australasian partner who could host their dryer and used by companies in the region. The Food Bowl, part of NZ Food Innovation Network is currently assessing whether this equipment should be housed at the Food Bowl on behalf of the company for development purposes. This technology operates a license model where companies are licensed by product (e.g. dairy, meat, fruit etc) and by specific territories for use. The royalties paid then off sets the capital cost of the equipment.

Extrusion Porosification Technology

This technology works as a variant of upstream processing for spray drying. A “pre-drying” technology, Using continuous twin-screw technology, EPT™ The development of this technology has been via a collaboration between CSIRO (Australia) and Clextral (French company). It works via CO_2 injection for aeration and is suitable for high viscosity feed materials and high fat materials (up to 81% fat). The continuous process is useful in texturing powders to provide them with new functions i.e. coffee

Finished dried products are reportedly superior in terms of rehydration and functional properties due to lower spray drying temperatures that can be used. It is used as an adjunct to spray drying and overall also reduces the power consumption of the spray drying process.

Advantages

- Suitable for highly viscous materials
- Flavours can be added into the process
- technology can be used for numerous food, chemical and pharmaceutical products
- mixing capability, due to the interpenetration of the screws

Disadvantages

- Relatively new technology, product validation ongoing or yet to be realized
- The suitability for highly viscous materials also limits potential use

Evolum® Belt dryer

Clextral also have two other drying technologies systems, under the trade mark Evolum®. The belt dryers are mainly integrated into snack production line. The product is evenly spread on the belt by a dosing system that maintains a consistent thickness and ensures homogeneous drying. It is transported in fine layers on the belt at adjustable speeds, dried by gas or electrically powered forced-air ventilation at controlled temperatures. Throughputs from the three models provide users 300kg/h, 600kg/h and 1,200kg/h. The Clextral research centers are based in France and Tampa.

Dehumidifier Tray Drying Solution (Reximol)

Dehumidifier Tray Drying Solution (Reximol) is commercially available within New Zealand for small scale drying. The Tauranga Company provides mobile units within, including the NZ Food Innovation Network, (FoodSouth). This technology provides low temperature drying, 25 - 50C, upper limit approx. 70C and can manage a throughput of an approximately 500kg per day.

Advantages

- The drying unit is model which means it can be readily transported for drying of seasonal materials
- Applicable for drying nuts, seeds and particulate materials
- can be used as a cooling unit after cooking
- The most economic and lowset capital drying technology we have found during the review

Disadvantages

- Commercial validation would be required for each product although some products have been undertaken
- Inability to fluidize materials means drying effectiveness is limited
- Batch drying suitable for smaller operations

Flash Dry Process (Enzaq)

The flash dry process is used by Enzaq to produce high quality green lipped mussel powder. The technology was developed to dry heat sensitive products such as milk and blood. The flash dry process addresses the 5 main factors that affect the quality of green lipped mussel powder:

The information gathered from this report

1. Quality of raw materials at input
2. Enzymatic degradation
3. Exposure to air degradation
4. Exposure to excessive heat
5. Risk of product contamination through excessive handling

Although the dryer is not suitable for high sugar products, results to date for those products where sugars have been removed have been very successful.

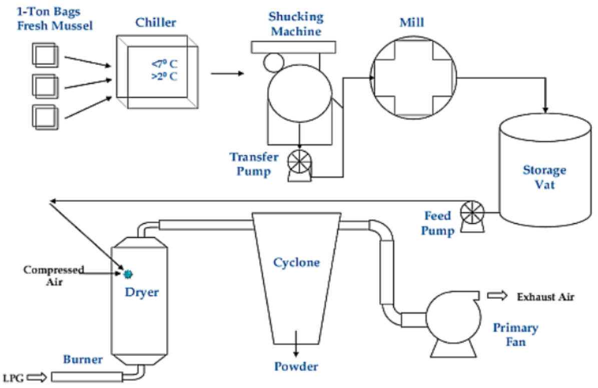
The process is well validated for bioactive and high protein products.

Advantages

- NZ Company based in Blenheim
- Applicable for drying nuts across product steams
- Product rarely exceeds 50ºC & exposed for 3 – 5 seconds
- Typically, 3% which ensures no microbial growth

Disadvantages

- Only one of these driers in the world, which is fully book for this year.
- Not suitable for high sugar products



Anhydro Spin Flash Drying (SPX)

Designed for continuous drying for cohesive and non-cohesive filter cakes. The dryer's capacity rages from a few kg/hour to 40 tons / hour. The product capability is also varied, from Organic Chemicals, Ceramics, Pharmaceuticals, food and waste streams.

Product is feed via a screw conveyor enabling high viscous materials to be processed. The rotor at the base of the drying chamber fluidizes product under heat. Airborne particles are passed through the top of the chamber before entering a secondary powder storage hoper.

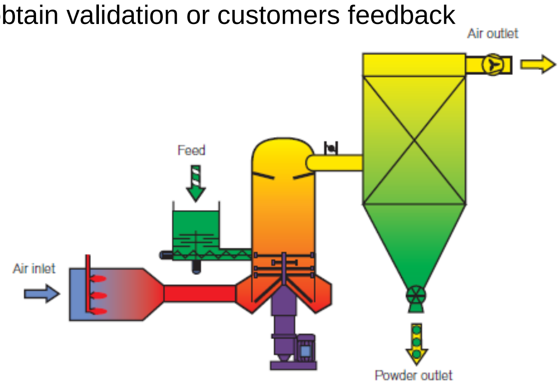
Inlet temperatures range between150-700ºC. The drying circuit can be maintained as a closed circuit using low oxygen inert gas supply such as nitrogen. This is beneficial for solvent based materials.

Advantages

- company office in New Zealand
- Wide variety and product applications
- High Viscosity products are no issue
- ISO, FDA and GMP certified
- Small foot print
- Comprehensive dryer's capacity rage
- One spin dryer is manufacturing Coagulated Blood products in Germany

Disadvantages

- To the project team's knowledge there are no dryers in New Zealand therefore unable to obtain validation or customers feedback



CURRENT & EMERGING NEW ZEALAND TECHNOLOGIES COMPANIES AND CONTACTS

It should be noted all technologies will not be applicable to all products and product outcomes will vary for those products that can be produced via some or all the technologies listed. We therefore recommend further investigation is carried out before considering a technology.

Cuddon Freeze Dry

Cuddon www.cuddonfreezedry.com

Cuddons Freeze Dry is well known and established within New Zealand employing over 90 staff. Drying units rage in capacity from 5.5kg to 1500kg with the company offering a Turn-Key Service. The FD1500 Freeze Dryer is the largest industrial freeze dryers and has a 1,500kg ice capacity, a 137m^2 shelf area and doors at both ends, both with observation ports. This industrial freeze dryer is ideal for large-scale operations, with the design specification of-40°C Saturated Suction Temperature.

The NZ Food Innovation Network has a Cuddon LT 80 Freeze Dryer operational in The FoodBowl (Auckland) and The FoodPilot (Palmerston North) houses a smaller version (capacity 20 litres) enquiry@foodinnovationnetwork.co.nz

This NZ Company is well known and has served the industry well over many years. The drying technology enables a wide variety of products to be freeze dried. Freeze-dried foods tend to retain most of their nutritional quality, taste, shape and size. Products do not require refrigeration, and packaged correctly can last for months or years. This process is often suited to those products difficult or not possible to dry via spray drying technologies.

Dry Fresh **www.driedfresh.co.nz**

Dry Fresh is another exciting New Zealand company operating in Waiuku. The technology is known as Osmotic Vacuum Drying in a Modified Atmosphere (OVDMA).

The process also allows fruit and vegetables to be infused with other fruit and vegetable extracts. Concentrates, anthocyanin or polyphenols can enhance bioactivity and/or vitamin and mineral content before the commencement of this rapid low moisture drying process. The process is unique in that it can be transported from site to site using a 20-foot container. This allows processing in field or close to the source of the raw material.

OVDMA drying process does not affect the cellular structure of the product. This provides a stable material and is less likely to be hydroscopic in nature.

Although there are units operating at both Chantal Organics (Napier) and the Dry Fresh facility in Waiuku, the technology is still relatively new in commercial terms. This is batch process like that of Freeze drying

Flavorsense

Flavorsense is an American company established in California fourteen years ago, by founder Leslie Norris. Leslie is currently building a refractive window dryer in New Zealand with the aim to have the processing plant available in 2017. Expertise involves novel ingredient development. The plant will focus on extraction/concentration of Bioactives and flavours from botanicals and co-products. The founders experience not only covers conductance drying, but spray drying, freeze drying and IR drying and combinations thereof. Leslie understands creating the value proposition for new ingredients, enabling toll processing using conductance drying.

This technology will be the first for New Zealand and offers a valuable option to potential clients.

The plant has yet to be commissioned or a location defined, however once established the vision is to offer the following services:

1. Toll processing and dryer lease options
2. R&D services to develop value added ingredients and maximize the unique properties (nutrition, function) of the dried ingredients for use in healthy finished food products.
3. Process support services to create SOPs for dry ingredients currently dried using other technologies (i.e. freeze drying)
4. Toll processing services for when a dryer lease isn't practical
5. Dryer lease options when an on-site unit is the best fit. Some Refractive Window drying products can be very hydroscopic in nature and so the packing process is vital to ensure stability of the finished product.

FlavorSense Goals – (re: drying technology – we seek to implement a more efficient technology closer to the source of ingredients. This optimizes value to the grower, and nutrition and taste for the consumer.

Costs per dry kg out, are typically about 2x spray dry cost (but 10-50X stronger), and about ½ of the cost of freeze-drying. There is a very low electrical demand, low infrastructure costs as the dryer is self-contained, and one operator can run three dryers, decreasing labor costs. Efficient modular design keeps purchase costs low, often less than half of the purchase cost of a comparable capacity freeze dryer.
The lower power demands also reduce the installation costs, and generally have low building infrastructure requirements.
Throughput is continuous (i.e. dry kgs out per hour) depends on the dryer size, solids content and grind size of the product being dried. Typical dry kgs out range from 7-15kg

Like freeze drying very hydroscopic in nature, packing must be carefully controlled and it may mean the product must be packed immediately into consumer packaging.

Bucher Unipekin

http://www.bucherunipektin.com

Vacuum Freeze Drying - Bucher-Alimentech Limited is based in Auckland with the parent company operating from Switzerland. The Bucher organisation specialises in several fruit and vegetable processing technologies from in-feed, to milling, juice pressing, ultra-filtration, adsorption systems and evaporation. Technologies include milk and whey product evaporation, and vacuum drying systems for soups, flavours, malted beverages and coffee. In the past 30 years, the company has built over 100 processing machines around the world.

The Vacuum Belt Dryer manufactured by Bucher has automatic process controls and operate continuously. The Thermo Compressor with Condenser and Zeolate absorption enables efficient processing and flexibility.

The largest unit has a maximum evaporation of 325 kg /hr. This provides a continuous process option removing any need for manually loading or handling of trays which comes with a very high labour cost. There is a reduction of processing time from that of a conventional freeze drying system. The process maintains lower energy loss due to heat transfer by conduction instead of radiation with effective energy recovery. The drying technology is the only processing unit which is continuous and the ability to process dry solids, liquids, dairy and non-dairy. It has a low commercial foot print compared to that of a spray dryer and so has lower capital investment requirements.

Although the company is well known for build juicing plants in New Zealand and around the world, they have currently had no drying units within New Zealand.

However, there is strong discussion underway for a pilot plant 2017

FoodWaikato / AgResearch / FoodPilot/ Pacific Flavours

http://pacific-flavours.co.nz

Spay Drying - Pacific Flavours are experienced food technologists and offer a wide range of liquid and powder flavours designed for specific applications including bakery, beverage, dairy, confectionery and nutritional. The company can undertake trials or small commercial runs on a 25kg/hr drier. Pacific Flavours will also be installing a larger 250 kg/hr drier and have indicated this will be operational during 2017.

AgResearch have a small disc drier 1 -2 kg/hr, ideal for small scale trials or proof of concept work. It should be recognized there is a difference between the disc and nozzle configuration and so powder functionality which may not be representative during scale up. AgResearch do however have the ability undertake product development from reverse osmosis through to powder.

FoodPilot based at Massey University have compact and multi stage dryer (MSD) 30 kg/hr and a bench top dryer like that of AgResearch. The FoodPilot is well supported with other processing equipment and technical staff.

FoodWaikato have a 500 kg/ hr spray drier which is well positioned for scale up trials and commercial production. This plant is however limited to dairy or dairy ingredients due to MPI regulatory requirements because the plant manufactures infant formula and nutritional powders.

EnWave

https://www.youtube.com/watch?v=RsxY8cRJWWw

Enwave Engineering Group is a US based company who are currently negotiating to install the 10kW nutraREV onto The FoodBowl. This dehydration technology can process dairy, meat, fruits and vegetables, however is well known for its Moon Cheese distributed throughout Starbucks stores.

The process uses microwave technology under vacuum and so allows adjustment of the atmosphere and therefore reduction of the boiling point to under that of room temperature. The process has the added ability to bring the temperature if required to frozen state, accelerating traditional freeze drying methods. This ability to control the final temperature during processing assists the functional properties of the final product i.e. nutrients, colour and flavours.

A continuous process, with the ability to manufacture nutraceuticals. The technology is not limited in the type of material feed with both liquid and solid materials being effectively processed. The process accelerates traditional freeze drying methods. This is a new technology which is yet to be fully commercialized. Microwave technology maybe questioned by some consumer groups however most consumers now have microwaves in the home. Power usage is claimed to lower per kg than freeze drying however there is no available data for this report.

ENZAQ

http://www.enzaq.com

Enzaq is experienced in green lipped mussel (Perna Canaliculus) powder manufacturer. Specialists in providing high quality green lipped mussel powder to the functional health foods, health professionals and veterinary industries. Through the flash dry process, Enzaq can manufacture the mussel powder quickly and retain highest quality level of nutrients which are normally lost compared to freeze dry methods

Peter has previous experience working with MPI providing fundamental experience in the food Industry.

The plant is at capacity for the next year however there is scope to expand dry capabilities.

Although the plant is experienced in mussel powder other non-seafood products have been validated providing the sugar concentration is low

SPX

http://www.spxflow.com/nz

SPX is working with food and energy producers all over the world, including customized solutions as well as individual components. Although designed in the 1970"s, as noted earlier in the report the spin technology is not currently in New Zealand and remains an untapped potential technology.

SPX is however experienced in other forms i.e. spray drying and have built 3 plant within NZ to date, two of which were Danone's Balclutha and Fonterra's Studholme plants.

The spin flash dryer is more cost efficient to that of spray drying. This is due to the evaporation process pre-drying. Because the spin flash dryer can receive high solids (cake) every 5% increase reduces drying costs by 20%

The spin flash dryer has a relatively low foot print and over all capital requirement compared to the spray drier. An equal 400 kg/hour comparison would need 50m^3 build to the 700m^3 spray drier.

Drying Solutions (Rexmoi)

http://www.dryingsolutions.co.nz

Based in Tauranga the dryer was originally developed to dry nuts at lower temperatures. Regardless of the technologies original intent the drying unit has become very flexible from cooling to drying all types of products.

Processing options include:

- Removing moisture from products or atmosphere
- Controlling moisture in products or atmosphere
- Low temperature cooking
- As a cooling tunnel (e.g. hot products from an oven to a lower temperature)

Drying Solution's hire units for trials and developing the recipe or products. This then allows for a unit to be built to your specific needs. The company has successfully dried various products which are sensitive to temperature.

Drying temperatures are typically between 15ºC and 60ºC, with an aim of having a temperature range from -5ºC to 70ºC. The ability to preheat product prior to drying (e.g. from frozen) is and added benefit. Running costs are as low as $10-$15 per 24 hours depending of cost of power and unit model.

This technology was the most affordable unit on the market throughout the project review and the most cost effective to run.

PROJECT ASSESSMENT & CONCLUSION

The report has discussed a wide range of manufacturing technologies; we acknowledge there may be other technologies not covered within this report. We believe the facilities within New Zealand are limited, particularly for products of non-dairy origin. It was the intention of this project to define the appropriate technologies and highlight potential opportunities or solutions.

We acknowledge the opportunity for a non-dairy toll manufacturing plant, however synergies between commercial entities where appropriate would need to be established. This would take a collaborative effort, key industry players would need to come together to invest in commercial scale facility. Shared learning's are on offer from FoodWaikato, providing an example of an open access model to grow New Zealand companies and exports. Through the interview process with companies there was a clear message that protecting intellectual property was high on the agenda for most. Cost associated in R&D are significant, furthermore the capital cost restricted independent investment. There are two options to resolve the collaborative approach (1) investors which are non-competitive share the processing plant or (2) independently managed facility like that of FoodWaikato, where IP is restricted to the management team and the brand owner.

Throughout the review process it was evident; no one technology will provide a single solution for all products. Two fundamental issues stand in the way (1) Product diversity including composition and volumes would require opposing drying technologies i.e. freeze drying vs. spay drying and batch vs. continuous. This becomes even more difficult when planning raw material and packing process requirements. (2) Regulatory and consumer requirements will define what the plant can manufacture. It would be nearly imposable to maintain Halal status for Berry powder and then manufacture pig blood products.

Two distinct models define the right technology for companies when investing. (1) Consideration should be given to production planning, high capital costs dictate full plant utilization (24/7) and processing volumes will dictate a continuous or batch process. (2) The right technology to produce a product that is fit for market - the total consumer experience and product satisfaction is critical. Producing a product containing naturally high sugar through a high heat process, turning into to a sticky sold object when exposed to oxygen, is not a good experience.

We have reviewed possible drying technologies but must ensure the feed stream and final packing process is not forgotten. Like any dairy spray dryer, once the processing conditions are validated for each specification, it just about monitoring the process. However, if the feed material, air drying conditions etc. change, the final product and quality may vary every time. Controlling moisture contents of hygroscopic powders through effective milling and packing process is essential to maintain high quality product. Barrier packing materials will assist shelf life and positive consumer experience.

We are reluctant to select one technology as each of them is fit for purpose. However, there was one key finding through this review for high sugar or acidic foods. Those technologies providing low temperatures $<40^{0}$C and or under vacuum provided some interesting results. The ability to provide the market with natural free flowing powder for the shelf life of the product, should maintain value in the market.

In regards to fruit and vegetables, seasonal variation of the growing season remained a significant issue to those interviewed. Full plant utilization all year round is essential to an investor of new technology given the capital investment. Resolving this issue may mean pre-processing or freezing materials post-harvest, any associated cost must be considered.

Market opportunity is a gap preventing commercialization, particularly for those in the R&D space. Our market research clearly found gifted businesses, supported by entrepreneurs. However, the product must be supported by market demand, understanding what the consumer is looking for remains fundamental for a sustainable business model. The product price point should be understood to balance capital investment and ongoing operational costs, while scale up ability is essential as market demand increases. So how do we minimise the risk while undertaking products, market and technology validation.

One solution is to provide technology for validation. The paper outlines current drying opportunities within New Zealand; however, Bucher Unipekin and FlavorSense are providing new solutions for New Zealand in 2018. FlavorSense are currently building a refractive window dryer for trial and commercial production, while Bucher Unipekin will provide a pilot plant for product validation.

Figure: Bucher Unipekin DryBand Pilot coming to New Zealand

Developing technology opportunities will provide validation and commercialization; however, his will also will create competition. For New Zealand companies to retain a sustainable valued proposition, we must restrain from commoditising value add products. Innovation of by-product from foods not for consumption was not covered in the paper, however should not be forgotten. Wallace Corporation are a perfect example of using biopolymers for technical use, furthermore scientific studies are looking at grape skins as potential bio-fuels. The technical use of foods remains open for ongoing research and development.

SUPPORT & CONTACTS:

For enquires relating to this paper email: shane.kells@wipltd.co.nz, or

enquiry@foodinnovationnetwork.co.nz,

BPA Virtual Pilot Plant Database for further processing options:

https://vppn.bioresourceprocessing.co.nx

PROCESS FLOW MAP.

Some process options identified may only be applicable for specific sub-applications, or be dependent on availability of a suitable solvent or adsorbent. Processing steps may also be used in combination – for example water content reduction by falling film evaporation followed by a final drying step suited to a viscous or solid final product. TABLE 11-

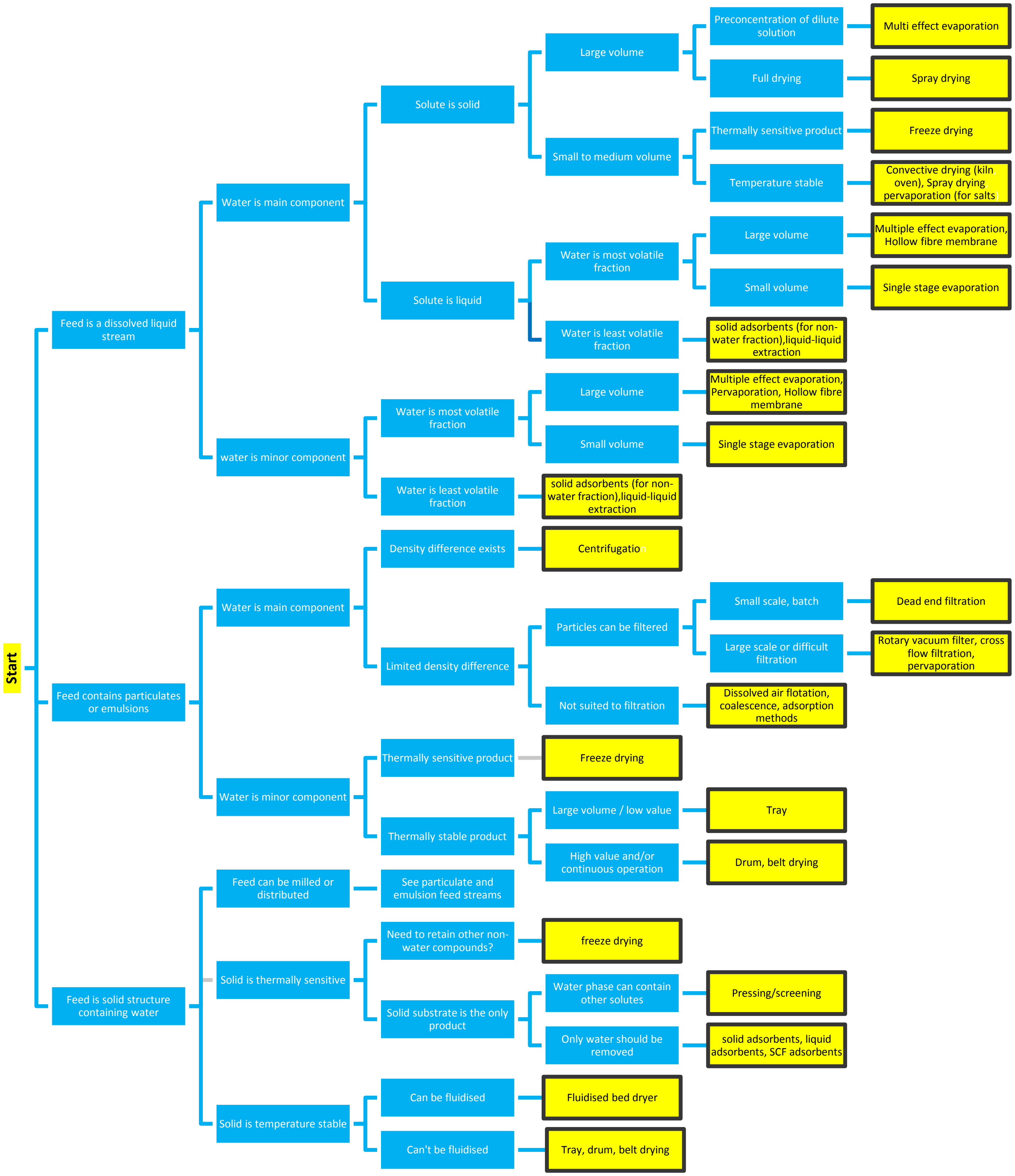


Table 12– **SUITABILITY OF VARIOUS PROCESSING METHODS FOR DIFFERENT TYPES OF OPERATION**

Suitable for: (green)

Possible, or conditionally suitable for: (yellow)

	Evaporation									Filtration						Adsorption			Density Sep		
	Single stage vacuum evaporation	Multi effect vacuum evaporation	Freeze Drying	Tray/Kiln/Oven/Air Dryer	Rotating drum	Fluidised Bed dryer	Moving Belt	Dryer with indirect heating	Spray drying	Static filter bed / filter press	Pressing / screening / de-juicing	Cross flow filtration	Moving belt / rotary vacuum filter	Pre-evaporation	Hollow Fibre Membrane	Solid adsorbents	Liquid / Liquid extraction	SCF/Liquid extraction	Coalescence / DAF	Centrifugation	Water displacement
Miscible liquid phases	Suitable	Suitable													Suitable	Suitable	Suitable	Suitable	Possible		
Dissolved solids	Possible	Possible	Suitable	Suitable					Suitable	Possible	Possible	Possible	Possible	Possible	Possible		Suitable	Suitable	Possible		
High water content	Suitable	Suitable							Suitable	Suitable		Suitable	Suitable	Suitable	Suitable	Suitable	Suitable		Suitable		
High solids content			Suitable	Suitable	Suitable	Suitable	Suitable	Possible		Possible	Suitable										
Solids to dryness			Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable							Possible	Possible	Possible			Suitable
Liquids to dryness	Suitable	Suitable												Suitable	Suitable	Suitable	Suitable	Suitable			
Partial dewatering										Suitable	Suitable	Suitable	Suitable				Possible		Suitable	Suitable	Suitable
Large solid substrates			Possible	Possible				Suitable			Possible					Possible	Possible	Possible			Suitable
Thermally sensitive compounds	Possible	Possible	Suitable					Possible		Suitable		Suitable	Suitable	Suitable	Suitable			Suitable	Suitable	Suitable	Suitable
Shear sensitive solids			Suitable	Suitable	Possible	Possible	Possible	Possible	Possible	Possible	Possible	Possible	Possible				Possible	Possible	Possible	Possible	Suitable
High Volume Flows	Suitable	Suitable				Suitable	Possible	Possible	Suitable		Possible	Suitable		Possible	Possible	Suitable			Suitable	Suitable	
Low operating cost	Suitable	Suitable		Suitable	Suitable	Suitable	Possible	Possible	Suitable	Suitable	Suitable	Suitable	Suitable		Possible	Possible	Suitable	Possible	Suitable	Suitable	Suitable
Low capital investment	Suitable			Suitable	Possible	Possible	Possible	Possible	Possible	Suitable	Suitable	Possible	Possible			Possible	Suitable		Possible	Suitable	Possible
Water remediation	Possible	Possible	Possible							Possible		Possible	Possible	Possible	Possible	Suitable			Suitable	Suitable	