OKARA

Overview of Current Utilization

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1.0 Summary

Okara is the by-product of soy beverage and tofu production. It contains protein and fibre which have value and which can theoretically be used in food products that meet market demands and opportunities. Okara, however, must be processed quickly in order to maintain its integrity. This processing can be expensive and as a result, economic feasibility typically discourages the use of okara in human food. If these barriers can be overcome there may be an opportunity for companies to benefit and the soy industry may be able to realize lost potential.

Soy 20/20 has conducted an analysis of the current okara situation. The potential to process and use okara in food products is limited by economic issues. Nonetheless, Soy 20/20 is supportive of efforts to investigate the use of okara as a food ingredient. A value assessment of the opportunity and specific recommendations are provided in this report.

2.0 Okara description

Okara is the residue which is produced from the production of soy milk. It contains most of the carbohydrates, some of the protein and a small portion of the oil from soybeans.

It is a white by-product, resembling wet sawdust. Okara is high in fiber and protein. It is traditionally used as a food ingredient in Japanese soups, salads and vegetable dishes. It is often said to resemble coconut in its texture and form.

Moist okara from soymilk production has about 80% moisture. Okara resulting from further centrifugation can have as little as 65% moisture. The protein content of okara can vary widely and should be tested to determine exact percentages. Some sources indicate that dry okara has 24% - 40% soy protein, but, according to the USDA Human Nutrition Information Service Agriculture Handbook No. 8-16, wet okara has approximately the following nutrient composition:

Figure: Nutritional Composition of Okara

PER 100 grams of wet okara		
K calories	77.0	
Water	81.6 g	
Protein	3.2 g	*(16% protein on a dry basis)*
Carbohydrate	12.5 g	
Fiber	4.1 g	*(21% fiber on dry basis)*
Calcium	80.0 mg	
Iron	1.3 mg	
Thiamin	0.02 mg	
Riboflavin	0.02 mg	
Niacin	0.1 mg	

In general, 250 kg of okara is produced for every 1,000 litres of soy beverage. Then the 2003 Canadian soy beverage consumption (not production) of 40,099,738 L, would translate into approximately 10,024,934 kg of okara per year.

3.0 Uses of Okara

3.1 Animal feed

Most okara is used as animal feed for livestock producers (swine and dairy) in close proximity to soy beverage production facilities. Okara used in this manner:

- provides excellent and abundant nutrients for livestock production.
- has demand among local livestock producers
- relies on local use to reduce or minimize transport costs.
- eliminates cost of treating, or handling in other forms.

3.2 Fermentation Substrate

The potential to use okara as a fermentation substrate for ethanol or methane production has been considered, but few details on the feasibility are available.

3.3 Fertilizer

Where livestock demand is not great enough to handle production, okara can be diverted for disposal onto fields as it can contain some nutritional properties for plants and soils, including organic matter. It can also be turned into compost for similar uses.

3.4 Pet Food

Okara can be used in pet foods as it contains high levels of extenders and protein. In this use, it must be dried completely and pelletized in order to allow for easy handing and possible reformulations into pet foods.

3.5 Food product

Okara can be used in a variety of food products. It can be used wet, in dried form, or as a paste in various food products from meats to baked products. Okara contains valuable components including soy fiber and soy protein.

The market potential of products that are high in protein and, in particular soy protein, is strong (see 9.0). Soy protein consumption among North American consumers is growing due to increased attention to health and new research on the positive effects of soy protein in the diet. The market for products containing soy protein in any form is therefore, growing and offers a great deal of potential for innovative firms willing and able to capitalize on this market opportunity.

Okara as a food has been referenced historically, but under small scale, home production applications. In these situations it is used mainly in soups and in vegetable dishes. Although used in some products commercially since the 1970s, it is not used extensively. Large scale commercial soy beverage production facilities are not using or selling okara for food purposes. Only one Canadian company is known to use okara in food products by freezing it immediately after production, storing it, and using it in a frozen state in a food processing operation. The total amount of okara salvaged and used is relatively small compared to the total amount of the production. Overall, the use of okara in foods is not prevalent anywhere in the world.

Anecdotal evidence suggests that commercial soy beverage producers are interested in, and actively investigating, the potential to better utilize and add value to okara, but few details exist on these confidential, strategic planning efforts.

In other circumstances, companies are re-evaluating the soy beverage production process to virtually eliminate the production of okara all together. Using new technologies from Switerzland (namely from Buhler Ltd.) soymilk can now be produced from an ultra fine, de-hulled, full fat soy powder which is dissolved in water leaving almost no pulp or okara byproduct.

4.0 Current utilization of okara for food use

Little okara is being used in the food industry today. One firm in Ontario is using okara in the production of baked soy products. This company is obtaining fresh okara from a soy beverage producer and quickly freezing it before shipping it to a production facility. Here it is used, without further processing, as an ingredient in consumer ready products.

For economic feasibility and shelf life reasons, okara must be processed in some fashion in order to facilitate its use in food products. Given the cost and technology required to process okara and the relatively low value of the product, no large scale primary processing of okara is occurring commercially in Canada. However, an investigation into primary processing options is warranted.

5.0 Barriers to the use of okara in food

5.1 Rapid degradation

Okara begins to degrade as soon as it is produced. Even refrigerated okara spoils in less than 2 days. Thus, okara must be used or processed at the site of production in order to be feasibly utilized in food production.

5.2 High costs of drying

Drying okara is one method of salvaging product for future uses in food. This process, however, requires specialized equipment and is energy intensive. The resultant costs can be extremely high relative to the value of the product. This is the major factor limiting the commercial use of okara worldwide.

5.3 Feasibility of freezing

Freezing is an alternative method for handling okara, especially when a higher moisture content in the food formulation is desirable. This process requires infrastructure, a great deal of energy, and continuity along the entire transportation chain. Thus, the economic feasibility of handling and using frozen, wet okara, especially in large quantities, is limited.

5.4 Strategic Relationship Building

This topic is not necessarily a barrier to use, but it is worthy of consideration. It is an issue which Soy 20/20 can manage, through its role in soy industry development.

Because the procurement and supply of okara depends entirely on its production, strong relationships must be built and managed with soy beverage companies. As a result, and especially where okara is to be used for food, consideration must be given to:

a) maintaining the supply of product and
b) arranging the processing, handling, transportation, and purchase of this product.

In some cases where the feasibility of sourcing okara for food uses is feasible, shared arrangements for the drying and or transportation may be an option. Regardless, trust and sharing of mutual goals will be important for any company considering long term use of okara.

Given that only one known food manufacturing company is currently sourcing okara for use in food, and given that relationship is confidential, there are no templates or organizations to direct such a venture. This area can be further developed if there is mutual interest, feasibility can be established and moved forward.

5.5 Alternative protein sources

Given that there are various sources of protein and fiber available on the market for food use, at reasonable costs, the attractiveness of utilizing okara for this purpose is not strong. The attractiveness is lessened more when high processing costs are considered.

In most cases, the estimated value of the okara does not currently justify the costs associated with primary processing.

6.0 Solutions to barriers to the use of okara in food

6.1 Process or use okara as soon as it is produced

6.2 Investigate drying costs (equipment and energy)

6.3 Develop entirely new market channels for premium priced products that add enough value to make okara processing economically feasible

6.4 Develop strategic alliances among companies (soy beverage producers, food processors, farmers) to reduce costs, share expenditures and maximize value

7.0 Options for primary processing of okara for use in food

7.1 Freezing

This method involves freezing the okara immediately after it is produced for use at another time. It is highly recommended that freezing occurs near the facility where okara is produced with actual utilization occurring elsewhere. To manage okara in this fashion requires:

- large scale equipment to freeze okara quickly, and thoroughly;
- freezer storage space to store frozen okara;
- transportation systems to move frozen okara to food facilities;
- systems to handle and utilize frozen, high moisture product; and,
- detailed costing transportation costs, energy requirements, and storage to ensure feasibility.

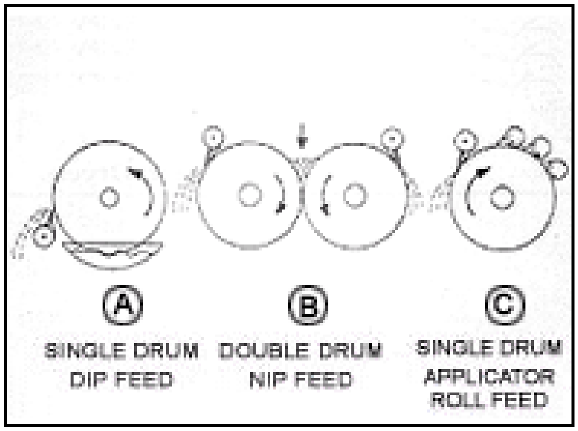
7.2 Drying

This method involves drying okara so that is can be used in formulations with less moisture and without the need for freezing. As in other food processing applications, drying is a high energy process that can be expensive and that requires advanced technology. Reducing moisture requires careful consideration of economic factors and end product integrity. There are different options for drying high moisture product, although none are currently being used on commercial scale for okara in Canada.

7.2.1 Double Drum (Roller) Drying

This process may be the best technology for drying okara. It is used to dry materials of similar moisture, such as mashed potatoes. This process involves depositing material between two heated, rotating drums (also known as barrels or rollers). Pressure exerted on the material by the adjacent drum squeezes out water while the high temperature of the drum surfaces dries the material very quickly. The material is left on the drum surface in a thin layer which is then scraped off and collected.

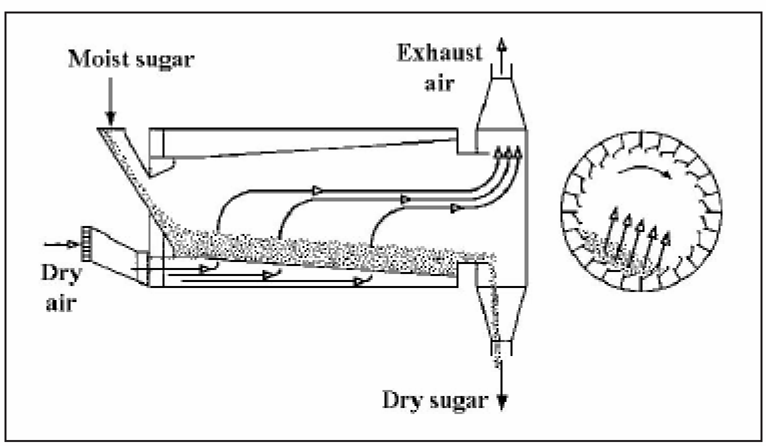
Figure: Drum Dryer



7.2.2 Cascading Rotary Drying

This process has been tried successfully in okara processing in the past and may be a good fit for potential drying. These dryers are characterised by a slowly rotating cylindrical drum, which is normally inclined at a small angle to the horizontal. Material is introduced into the upper end and dried product is withdrawn at the lower end. Rotary dryers can vary according to air flow direction and inclination.

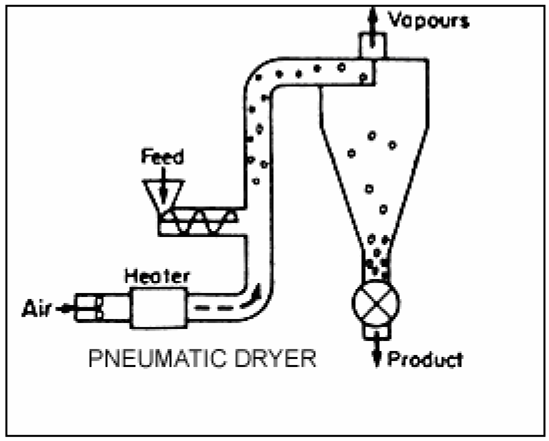
Figure: Rotary Dryer



7.2.3 Spin-Flash Pneumatic Drying

In a flash pneumatic dryer, the material is conveyed rapidly in an air stream, with the velocity and turbulence of the stream maintaining the particles in suspension. Heated air accomplishes the drying. Some form of classifying device is often included with the equipment.

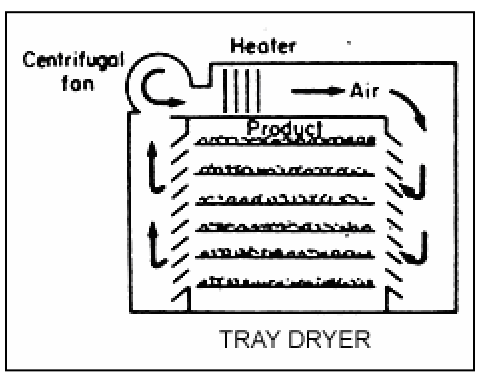
Figure: Pneumatic Flash Dryer



7.2.4 Tray, Bin, Tunnel and Belt Drying

These processes move material into or through an environment of moving, hot, dry air to remove moisture. The process is simple, but can be slow to dehydrate very wet materials and will cook the solid portions. This method of drying is simple, but not rapid and not energy efficient.

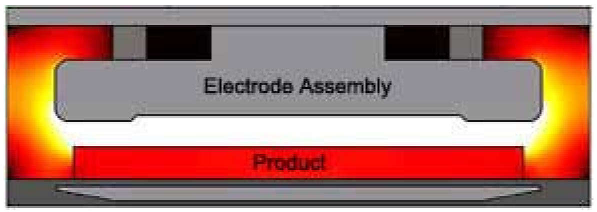
Figure: Tray Dryer



7.2.5 Wave Heating and Drying

The use of microwave, infrared, or radio frequency waves to heat and dry material is emerging in the food industry. This type of system offers uniform, rapid drying. Although more recently developed (than surface and air drying technologies), companies are developing equipment and processes that can be used for batch drying and dehydration of food products. However, this method would likely be too costly and too heavily reliant on high expertise for okara drying.

Figure: Infrared Dryer



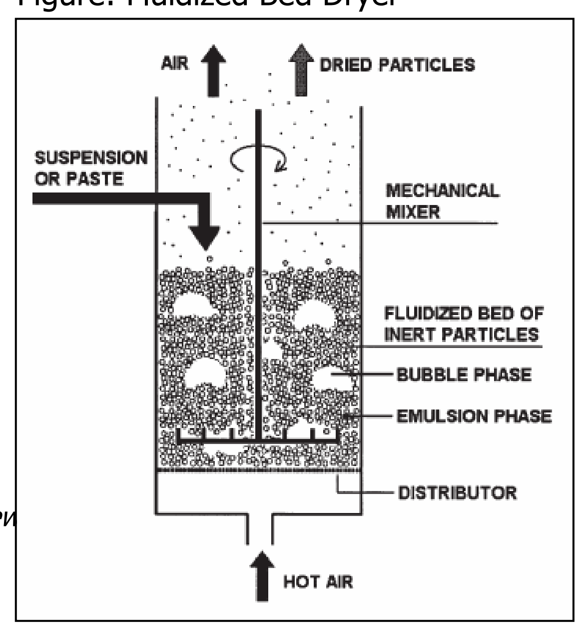
7.2.6 Sonic Drying

The technology uses pulses of intense, low frequency sound waves combined with lower temperatures to remove moisture without cooking materials, in a shorter period of time. The technology is relatively new and may be quite costly. It is not a major option for drying okara.

7.2.7 Drying in a Fluidized Bed of Inert Particles

This method of drying is gaining interest in the food industry, and is being looked at as a possible option for okara drying. Some research from Japan highlights the use a bed of inert particles to dry okara and save it from spoiling. This type of system may offer some potential for okara drying, but may be heavily reliant on technology and can be quite costly in terms of capital.

Figure: Fluidized Bed Dryer



7.2.8 Dried okara co-product considerations

If okara production can be feasibly undertaken, consideration must be given to the production and handling of co-products. Given that primary processing mainly involves the removal of water from raw okara, water is the main by-product. For environmental and health reasons, this water must be handled appropriately.

7.2.8.1 Disposal

If water can be free of micro-organisms and contaminants, it may be suitable for release into the environment by spreading on agricultural lands or re-introducing it into water systems (septic, municipal drains etc.). Spreading on land will likely require government permits and/or land use agreements with land owners. Release into water systems will require ongoing testing and approvals from appropriate government ministries and departments. If the effluent water is not suitable for disposal, it may need to be handled and treated as a wastewater product, similar to sewage. The degree and details of this co-product handling will depend greatly on the location of the primary processing the facility, the volumes being considered, and the composition of the water co-product.

7.2.8.2 Value-added uses

No known opportunities exist to add value or re-market the water co-product at this time.

8.0 Possible secondary processing options for okara in food

Although barriers to okara utilization may limit its use in human foods today, there is a possibility to add value to dried okara, thereby making recovery and utilization more feasible, from a cost perspective.

8.1 Milling

Recently, some food based companies have been looking to add value to by-products through further processing. For example, wheat millers are now investigating the idea of producing a new ‘flour’ product from wheat and other cereal germ, or bran. Although there are many technical challenges, the expertise in the industry exists to add value to dried okara by further processing it into a more consistent, fine flour type product. The opportunity to add value to at least some dried okara product by milling it into a new product may be realized through utilization of expertise in the milling industry.

8.2 Paste production

One Japanese firm is currently claiming to produce and market an okara paste using a patented technology. If economically viable, this paste could be more useable and stable while retaining desired nutritional properties.

9.0 General Overview of Markets for Soy Protein

The main potential uses for okara in food products are in bakery and meat products. The following briefly outlines the market situation and an analysis of each opportunity.

The utilization of okara as a food ingredient will add value to the total production costs associated with soy beverage production, thereby, improving profit margins and efficiency to create strong businesses. It may also provide an opportunity to those that can properly utilize and market products containing okara.

The use of okara will not, however, do much in the way of adding value to the bottom line of Canada's soybean producers or primary processors because the okara is a by-product of further chain processing. Costs savings or margin increases at this stage of the chain are seldom, and not necessarily, passed on to the suppliers of the raw products.

9.1 Bakery Products Market

Okara, dried or in a full moisture form, can be used in bakery products to add fiber, protein and bulk. It is best suited to bakery products not using yeast, including cookies, muffins, bagels, etc.

9.1.1 Market Overview

Canada is growing in importance as a producer and exporter of bakery products. The total value of manufacturing shipments has increased more than two-fold in the last ten years. A significant contributor to this growth in bakery manufacturing has been the growth of the export market. The incorporation of soy into bakery products has the potential to carry soy protein from Canada to global markets. Given that soybeans are not grown in the United Kingdom (U.K.) or France these countries represent a significant opportunity for soy protein as a food ingredient from Canada.

The majority of soybean production, primary soy processing, and bakery manufacturing in Canada, occurs in the great lakes corridor.

9.1.2 Market Analysis

With a growing population, a thriving food processing sector and a strong soybean grower base in central Canada, there is a real opportunity for all players in this industry to realize incremental value from soybeans. The use of soy protein as a food ingredient, even at low percentages, has tremendous potential.

Soy protein is increasingly finding its way into a broad range of mainstream food products. Soy protein promotes health and can interact well with other food ingredients.

The physical proximity of soy bean growing, primary processing, soy beverage production, and baking provides Canada with a competitive advantage in the bakery products market. Canada is well positioned to be a global leader in the development of a range of higher quality soy protein products that are individually suited to different product lines, creating higher value throughout the value chain.

There is a clear gap in Canada’s ability to move product from our globally leading soybean production and grain handling system to the food market. This gap will cost Canadians at least $11M in value per year. The domestic bakery industry represents a large scale market opportunity for soy.

Soy protein needs are currently being served by the United States (US) soybean processing industry. Food formulators only have access to commodity sources of soy protein, in the form of soy flour and soy concentrates, derived from the major crushers. Niche opportunities for domestic, natural, non-GMO, or organic soy protein sources may represent an opportunity for Canada.

There is an opportunity to utilize okara as a source of soy protein in food production. The ability to supply this market will depend on ensuring product quality and market access.

9.2 Meat and Meat Analogue Products Market

Okara can be used in highly processed meat products as an extender and source of protein.

9.2.1 Market Overview

Consumption of meat and meat analogues is the Canadian marketplace may be growing slightly, but is relatively stable.

Table 1: Meat consumption in Canada

	1991	1996	1999	2000	2001	2002	2003
Beef	33.28	31.45	32.60	32.01	30.74	30.46	31.98
Pork	25.86	25.99	30.09	28.69	28.94	27.83	25.17
Chicken	22.23	24.9	27.75	29.11	30.49	30.71	30.50
Turkey	4.54	4.12	4.16	4.26	4.22	4.27	4.21
Lamb	0.87	0.75	0.86	0.94	1.03	1.03	1.10
Veal	1.48	1.3	1.29	1.32	1.25	1.24	1.26
Meat Analogue	--	--	--	--	--	--	***0.26***
TOTAL	88.26	88.51	96.75	96.33	96.67	95.54	**94.48**

The market for meat protein is segmented by type of meat and by distribution channel. Between 30% and 35% of meat is likely consumed through food service channels. Beef maintains the largest market share at 35-40% with poultry in at 30-35%, pork at 20-25% and other meats accounting for 10-15%.In terms of value, fresh market retail remains the biggest category.

For the major meats, 30-40% is further processed and not consumed as whole muscle pieces. It can be assumed that much of the chicken and beef consumed in food service is in a further processed form and accounts for 20-22% of total consumption. Thus, only 10-20% of the further processed meat is purchased at retail and consumed at home.

However, processed meat categories in retail continue to grow (for example, frozen entrées up 15% and chili up 23% between 2001 and 2002). Likewise, the meat analogue market also continues to grow (16% increase from 2001 to 2002).

Highly processed deli and packaged meats are worth a combined $1.8 billion. Frozen prepared meal, excluding those made mainly of pasta and seafood, are valued at over $860. The meat analogue category is valued at over $58 million. Meat pies are valued at over $50 million and frozen pre-packaged meat category, excluding patties and seafood is worth over $35 million.

9.2.2 Market Analysis

The slight growth in overall meat consumption per capita combined with population increases, means that the demand for meat and meat analogues in the market will continue to be strong. The growing market for highly processed meat products means that there is an opportunity to incorporate meat analogues into meat products for cost and health reasons.

Okara may represent a cost effective, nutritionally valuable alternative form of protein. If it can be processed efficiently and readily incorporated into a variety highly processed meat products, it has the potential to reduce overall product costs while maintaining the nutritional properties of meat products.

The ability to supply the market with such a product will be dependent on price competitiveness and gaining market access (either independently or in partnerships).

10.0 Okara Opportunity Evaluation

10.1 Value assessment

There are challenges to capturing the value of okara. Okara contains high amounts of soy protein which is highly valued. Different values of soy protein from various sources are shown in the following figure. These are general prices as determined by price requests to major suppliers.

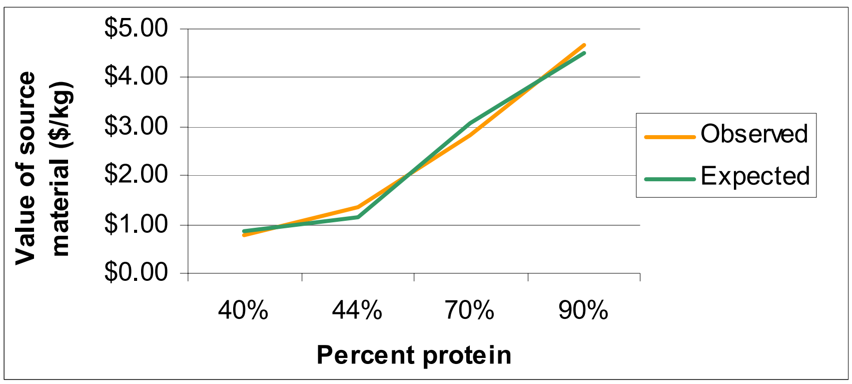
Table 2: Prices and protein contents of various soy protein sources

Protein Source	***% protein***	***$/kg pure protein***	***$/kg from source***
Full fat soy flour	40%	1.94	0.78

Low fat soy flour	44%	3.03	1.33
Soy protein concentrate	70%	4.02	2.81
Soy protein isolate	90%	5.17	4.65

We conducted a regression analysis to determine the effect of varying the initial protein concentration on the price per unit protein. We found that the protein concentration of a feedstock was an extremely reliable indicator of the price paid for protein (98% of the variation explained). This means that the food industry will pay considerably more for soy based protein when the concentration is higher.

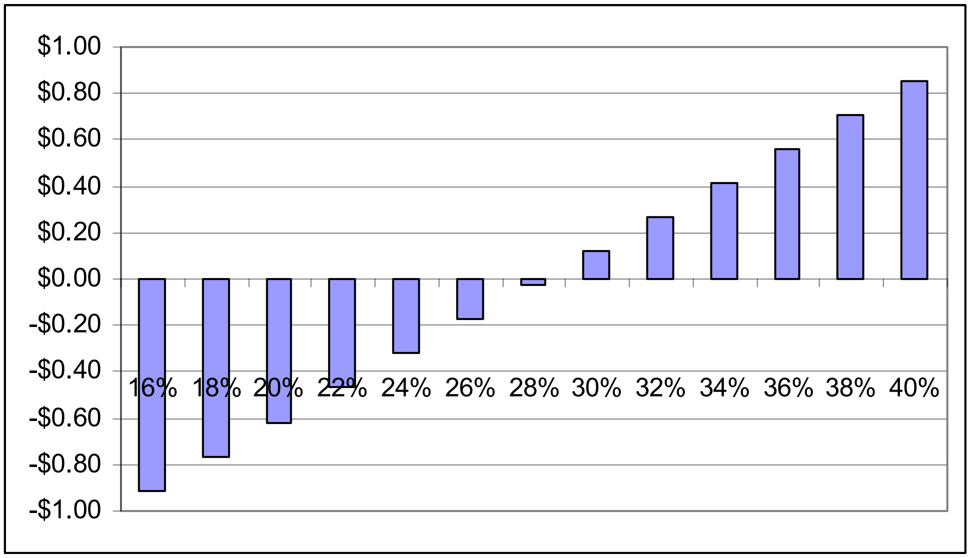
Figure: Expected and Observed values at various protein levels



Moreover, the relationship between how much industry is prepared to pay per gram of protein, and the protein concentration is entirely linear, thus suggesting that something real is driving the price points of the existing soy protein products.

From this, we can predict the value of a source of soy protein based on the protein content of that product. However, we know that there seems to be significant variance in referenced and real protein content of okara. Thus, we need to predict the value of that okara over a range of protein contents.

Figure: Value of okara at various protein levels in $CDN



As shown, okara carries no real value until has 28.5% protein. Although this calculation does not attribute any value to the other components of the okara (fibre, filling value, etc.). This is also the case with soy flour and it still provides a reasonable means by which to place value. Within this context, okara will have a very hard time competing.

If okara can be located and procured with more than 28.5% protein, it will have real value. The cost associated with drying, handling, transporting, and using that okara, however, must be less than the value, if it is a worthy endeavour. As protein contents rise above 28.5%, the value of the product increases, but must still be less than the cost of drying.

Basic calculations can be undertaken for the leading options for okara drying. These calculations do not include cost for obtaining drying equipment. They also do not attribute any value to fiber or extending value of the okara. They are based on the breakeven okara protein content and assume no cost for the procurement, transport, packaging or handling of okara. At 28.5% protein, the following table shows drying costs for okara.

Table 3: Drying costs for okara

	Pneumatic Dryer	Rotary Dryer	Drum Dryer
Drying capacity			
moisture content of okara	80%		

evaporative rate (pounds water/ hour)	22,154	13,000	10,000
volume of wet okara per hour (lbs)	31,203	18,310	14,085
volume dried okara per hour (lbs)	9,049	5,310	4,085
% mositure in product	9.0000%	9.0000%	9.0000%
volume dried okara per hour (kg)	4,040	2,370	1,823
Energy useage			
evaporative rate (pounds water/ hour)	22,154	13,000	10,000
thermal rqrmnt (BTU)	1,521	1,570	1,500
thermal useage (BTU)	33,696,234	20,410,000	15,000,000
thermal usage (J)	35,527,806,278	21,519,393,714	15,815,331,000
thermal usage (cubic metres natural gas)	910.9693917	551.779326	405.5213077
current Union Gas S Ont rate (cents per litre)	39.6	39.6	39.6
cost per hour	$360.74	$218.50	$160.59
cost per kg dried okara	$0.089301	$0.092178	$0.088068
Costs			
Percentage protein in wet okara	6.22%	6.22%	6.22%
Percentage protein in dried okara	28.5%	28.5%	28.5%
volume of protein per hour (kg)	1,153	676	520
Processing cost per kg of protein	**$0.31**	**$0.32**	**$0.42**
Regressed value	**$0.01**	**$0.01**	**$0.01**

This analysis shows that the cost of simply drying okara is greater than the value of the protein contained within. At this level, it does not make economic sense.

So, at what level does drying make economic sense? The point where drying cost is equal to value occurs where the protein concentration of dried okara is 32.2%. At this point, the predicted value of okara is $0.28. Not considering other very important costs (capital, transportation, etc.), and benefits (fiber value) okara must be at least **32.2% (7.03% wet)** in order to make economic sense. This figure could rise significantly when all marketing factors are considered.

How prevalent is such okara? It is difficult to know definitively the composition of domestically produced okara. Further research to test okara from a variety of sources should be undertaken to clearly identify the protein level and also identify any other beneficial compounds within.

Although only some of the soy beverage consumed in Canada is produced domestically, the Canadian influenced amount of okara production is estimated at approximately 10,025,000 kg. At 32.2% protein, and a value of $0.28/kg protein, the projected annual value of okara is at least $903,854. This represents a small yet significant opportunity that can be captured by the soy industry by utilization in food products, with or without additional processing.

10.2 Value Opportunity

The analysis shows that there may not be a significant opportunity for using okara in food production. There are two main factors which could change this picture:

i) Using okara at greater than 32.2% protein; and,
ii) Identification and valuation of functional, complex carbohydrates and fibres.

10.3 Recommendations

Soy 20/20 believes that companies or organizations willing to consider adding value to okara through use in food should be aware of the challenges and the economics.

Using okara as a food ingredient does not seem feasible and may not offer significant benefit to the industry.

Nonetheless, there is an opportunity to capture value by using okara to its fullest potential. Soy 20/20 is supportive of efforts that:

a) determine the composition of domestically produced okara
b) clearly identify the most efficient methods of preserving okara
c) investigate new uses for and products containing okara
d) build relationships between producers and potential users of okara
e) develop arrangements for the utilization of okara