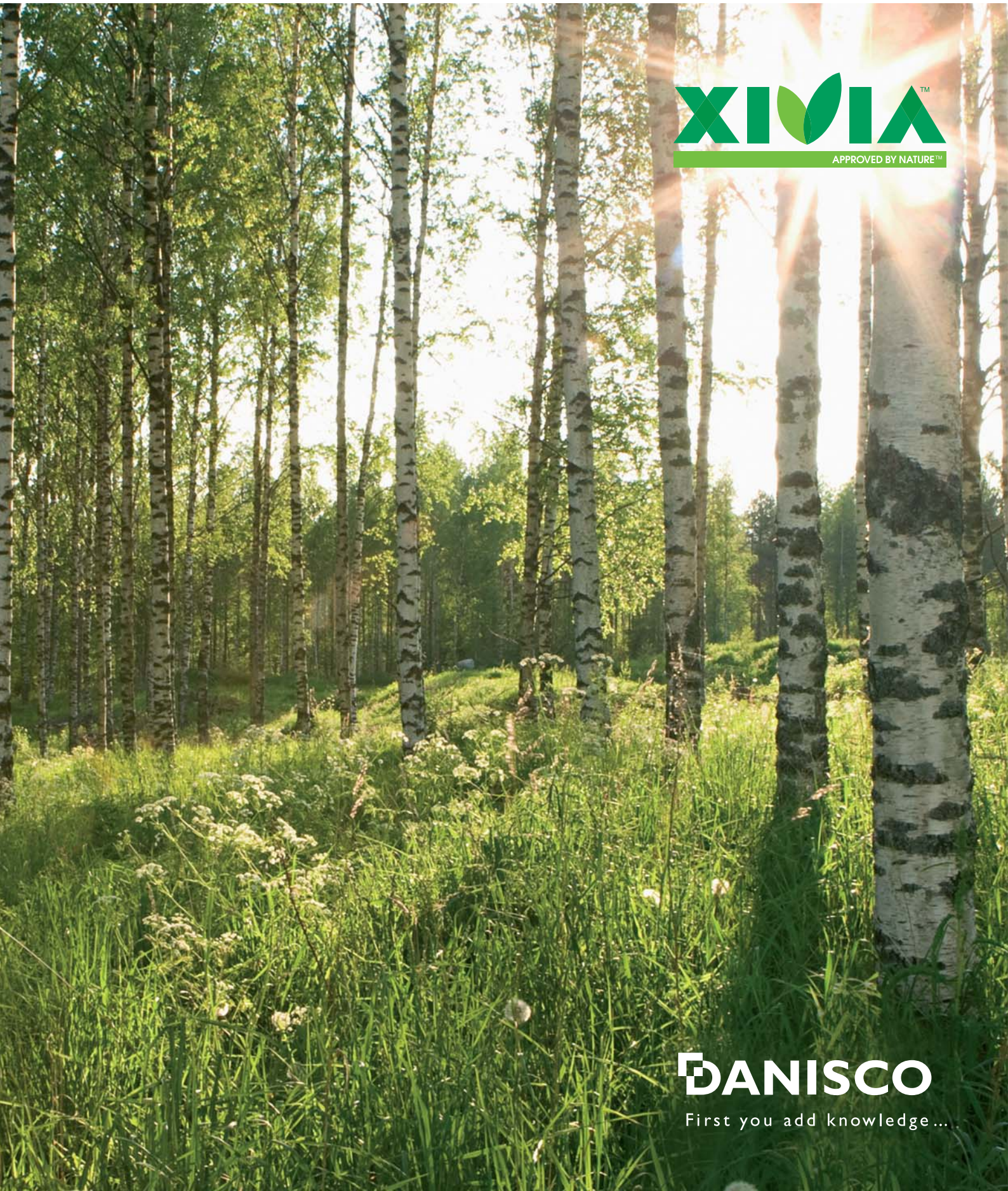
XIVIA™ White Paper

Sustainable and substantiated

For more sustainable, healthier products



Danisco commitment to sustainability

Over the last decade Danisco has proven to be a sustainability leader, with our demonstrated performance in reducing our value chain impacts and harnessing opportunities to address global challenges in food, health, chemicals and energy. By managing the risks and building capacity in our supply chain, reducing our operational, environmental and social impacts and delivering sustainable product offerings to the market, we have developed a differentiated business approach where sustainability challenges and concerns are seen as opportunities to advance impact reduction in our customers' processes and consumer applications.

Environmental and social impacts can occur throughout a product's life cycle: from raw material acquisition to production (cradle to gate) or from raw material acquisition to use and end-of-life (cradle to grave). We have fine-tuned our approach to include Life Cycle Assessment (LCA) and environmental footprinting to guide our product development efforts towards reducing our impact and to provide quantitative impact data to our customers, retailers and consumers.

Life Cycle Assessment (LCA) is used at Danisco as an analytical tool to quantify and interpret the environmental flows to and from the environment (including emissions to air, water and land, as well as the consumption of energy and other material resources), over the entire life cycle of a product or service. By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the improvement potentials and the environmental trade-offs.

Danisco Xylitol **(branded as XIVIA™)** offers unique benefits toward sustainability. This paper documents the findings of an independent comparative LCA of Xylitol production by two alternative production processes; the Danisco Wood Based integration concept (DWB), unique to Danisco, and the Biomass Hydrolysis Process (BHP), which is the conventional industry standard used by many of Danisco's competitors.

This assessment has been conducted according to the ISO 14040 – 14044 standards for comparative LCAs. The assessment results demonstrate (see chapter 3, figures 4 and 5) that the DWB integrated manufacturing process is 85-99% less impactful than the BHP concept, leading to a significantly less impactful and more sustainable product for our environment.

- **The carbon footprint of DWB Xylitol is 90% lower than when produced by the BHP concept.**
- **The DWB method requires significantly less energy (85% lower), has less impact on toxicity for both land (94% less) and water (99% less), and has less impact on ozone layer depletion (86% less).**
- **All other measured biomarkers were 85-99% lower for the DWB method.**

This document explains how the DWB integrated manufacturing process for XIVIA™ can be a key differentiator for customers in the global health and nutrition business. It also details why Danisco's Wood Based integration concept used in XIVIA™ manufacturing is superior to conventional biomass-based extraction technology.

1. Assessing the sustainability of Xylitol production in detail

EarthShift LLC conducted a comparative LCA for the two industry standard Xylitol manufacturing processes. The Biomass Hydrolysis Process, using corn cobs, and the Danisco Wood Based integration concept, a more modern extraction method based on utilising paper and pulp side streams as feedstock.

The LCA model is built around the production of 1000 kg crystalline Xylitol as a reference unit and takes into account the potential environmental impact caused by raw material use, air, water and soil emissions in 15 impact categories, from cradle-to-gate.

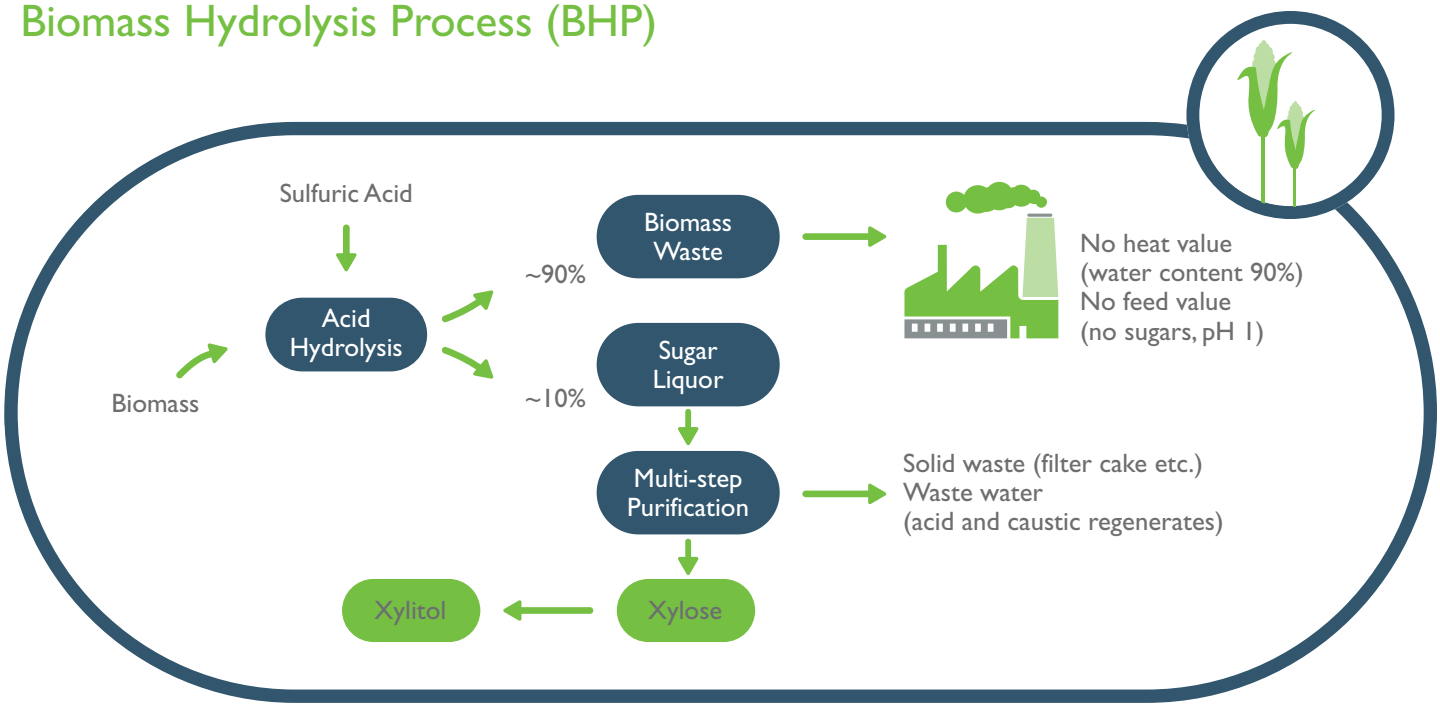
1.1 Biomass Hydrolysis Process (BHP)

The BHP concept is based on the use of corn cobs, which are what remains of an ear of corn after the kernels have been extracted. Owing to a high xylose content of more than 25% (Kabel et al.,2002), corn cobs serve as an attractive feedstock for Xylitol production.

After the corn cobs are brought to the facility, they are acid hydrolysed in order to breakdown the structural components. When submitted to this acid hydrolysis process, lignocellulosic materials such as corn cobs generate a hemicellulosic hydrolysate, consisting of solubilised sugars like glucose, xylose and arabinose. The extraction steps for xylose production following the hydrolysis are essentially purification and filtration.

The xylose is then converted into Xylitol. This involves hydrogenation of xylose followed by separation and evaporation to yield crystallised Xylitol. Figure 1 shows a simplified process flow diagram for biomass based concept.

Figure 1 - Process flow diagram representing a typical Biomass Hydrolysis Process (BHP)



1.2 Danisco Wood Based concept (DWB)

The DWB concept, an integrated process for Xylitol production, follows the same general process of purification and filtration to extract xylose and then Xylitol.

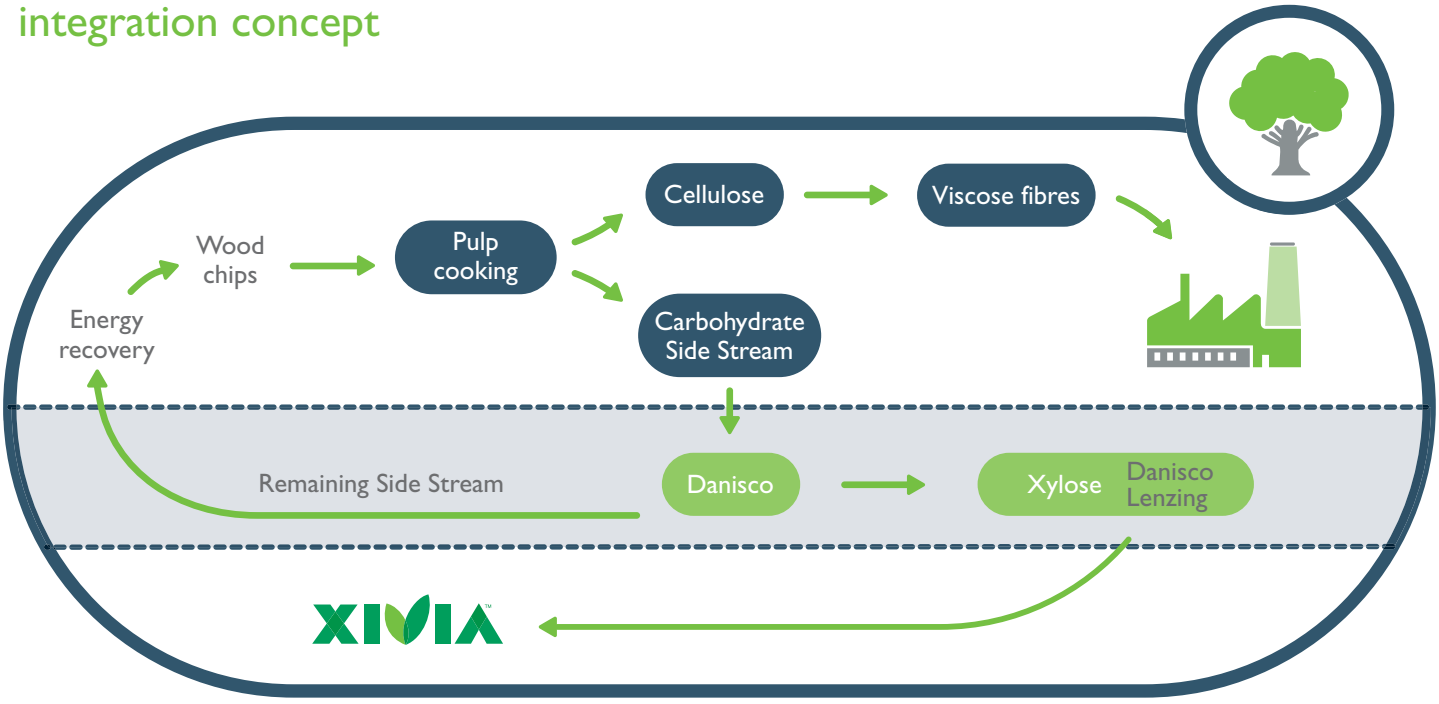
In the DWB process, the xylose producing facility is integrated with a pulp and paper plant. Pulp and paper plants typically produce a waste side stream – consisting of black liquor – that has a high carbohydrate content and energy value. The side stream is usually combusted to produce heat and electricity which is used internally to fuel the pulp production within the plant.

The DWB process uses only side streams from wood originating from sustainably managed forests. Our integration partners hold a number of certificates to provide proof of this sustainable approach (FSC, PEFC, SFI etc.).

The integration of xylose production with a pulp and paper plant takes advantage of the high carbohydrate content of the side stream and utilises this waste stream as feedstock. The xylose in this feedstock is already in a hydrolysed form, and therefore in the DWB process there is no use of acid for hydrolysis.

Once xylose is extracted, the remaining side stream with reduced xylose content and reduced energy value is returned back to the pulp and paper plant for incineration and energy production. For the purposes of this LCA, the production of xylose at the Danisco Lenzing plant in Austria and the manufacture of Xylitol at the Danisco Kotka, Finland plant were used. As xylose production causes the majority of the impact in the LCA, the choice of Xylitol production plant was found to have a negligible effect on the overall study results.

Figure 2 - Process flow diagram representing DWB integration concept



In order to ensure that both the processes produce a marketable product similar in quality, the quality specifications for producing marketable Xylitol were considered. Figure 3 outlines the quality criteria met by the two products.

Figure 3 – Quality Criteria for products from two processes

Quality Criteria	Maximum Allowed	BHP Process	DWB Process
Xylitol (HPLC Assay based on dry substance)	-	100.50%	98.5-101%
Moisture	0.20%	0.04%	<0.2%
Nickel	1mg/kg	<1mg/kg	<1mg/kg
Arsenic	0.5mg/kg	<0.5mg/kg	<0.5mg/kg
Heavy Metals	1mg/kg	<1mg/kg	<1mg/kg
Lead	0.3mg/kg	<0.3mg/kg	<0.3mg/kg
pH	-	5.6	5.0 - 7.0
Total Polyols (based on dry substance)	1%	0.02%	<1%
Melting Point	-	94.5°C	92 - 96°C

Source: Danisco

Since both the products are serving the same function, the material and energy flows for both processes were referenced to the production of 1000 kg crystalline Xylitol. The LCA model was built around this unit of comparison and are characterisedvalues depicting the potential environmental impact caused by energy and material use - and air, water and soil emissions in 15 impact categories.

2. Excluded data

Typically in an LCA, some aspects within the set boundaries are excluded due to redundancy or statistical insignificance. The scope and boundaries for this study excluded the impacts from human activities, such as employee travel to and from work.

Additionally, the following aspects of Xylitol are excluded from the scope because the same modeling and assumptions would be made for both the manufacturing processes (so the net difference in results would be the same):

- Distribution of Xylitol to the various markets. The markets for both the BHP based Xylitol and the DWB Xylitol are spread globally. Considering the global nature of the markets for the two products, the distribution impacts from both the systems are expected to be more or less the same. Therefore, the distribution was excluded from the main analysis. Nevertheless, the sensitivity of each system was tested by conducting a sensitivity analysis for distribution;
- Production of food products containing Xylitol (the same for both processes);
- Distribution of Xylitol in a food or beverage final product to the wholesaler and local grocery (the same for both processes);
- Purchase of Xylitol at the store and transportation of these products to the location of consumption. It has been assumed that all sources of Xylitol are being purchased at the same grocery store and travel the same distance to be consumed;
- Consumption of Xylitol, i.e. the impacts from human waste (the same for both processes).

3. Cut-off criteria

The ISO standards recommend a cut-off criterion to be defined for the selection of processes or flows to be included in the system boundary. The processes or flows below these cut-offs or thresholds can be excluded from the study as their contribution would be negligible. These criteria are mass, energy and environmental relevance.

Essentially, all physical flows associated with the production processes in this LCA were initially considered. To assess data quality, however, a cut-off of the environmental relevance based criterion was applied where the processes or flows with less than 1% contribution to the total environmental impact – as calculated by the IMPACT2002+ method – were considered negligible and hence excluded from the study.

3.1 Results

Results indicate that the environmental impacts associated with Xylitol production using the BHP concept are greater for all impact categories considered. **The main scenario in the study shows that the BHP concept results in environmental impacts that are 84% - 99% higher than those associated with the DWB integration concept.**

The LCA demonstrates that the Wood Based integration concept adopted by Danisco for XIVIA™ production is clearly superior in its overall environmental performance when compared to the BHP concept for Xylitol based on the environmental impact categories considered in the analysis.

Generally speaking, in both the systems, feedstock production as well as manufacturing, are important drivers of the environmental impacts. Furthermore, the sensitivity test for electricity grid proved that the results of this comparison are not sensitive to the plant location. It can be therefore concluded that the environmentally superior performance of the DWB integration concept is not likely to change if the plant is set up in a different geographical location.

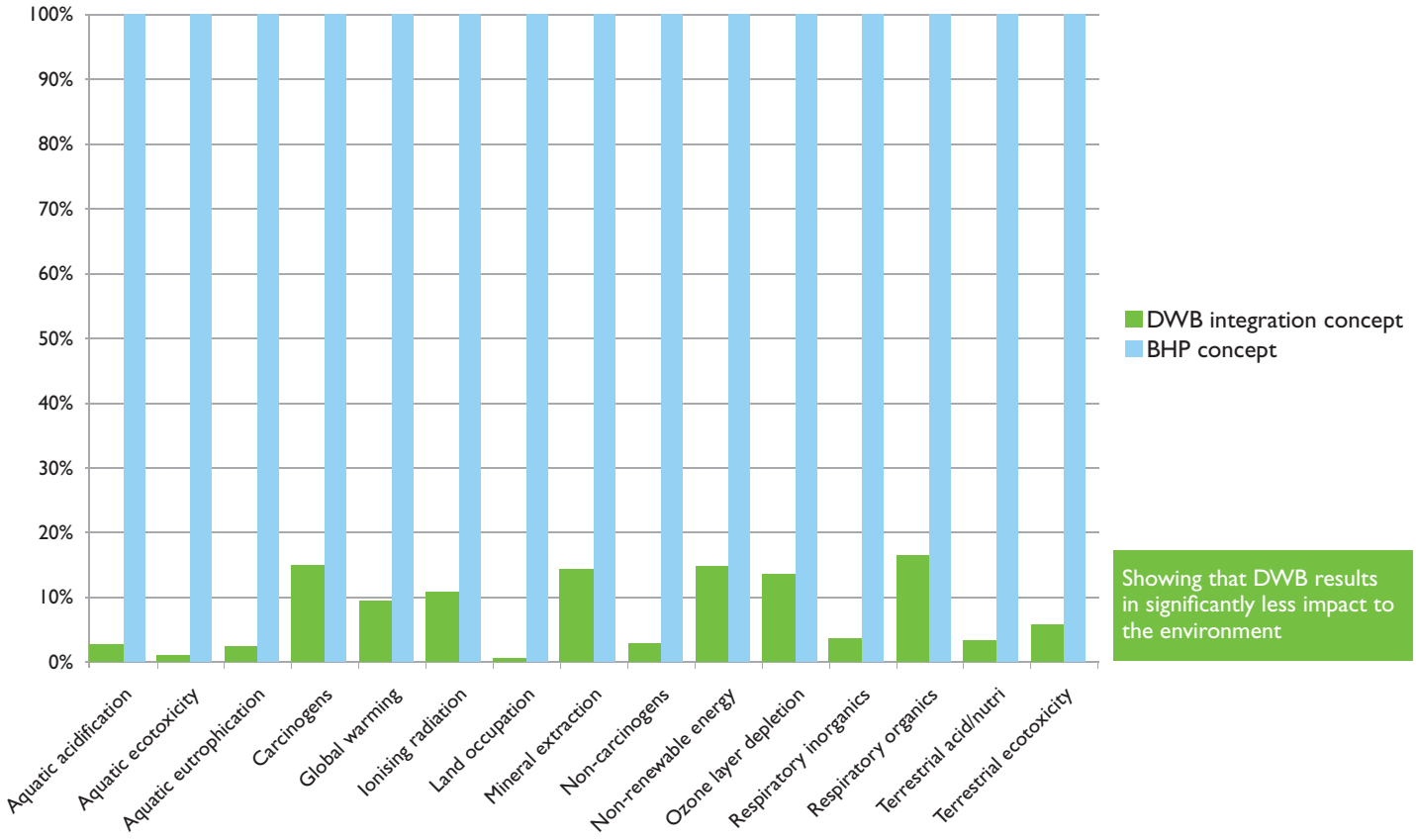
In spite of the uncertainties and limitations associated with LCA as a methodology, it is reasonable to conclude that in this case based on the results and many sensitivity analyses, the production of Xylitol by the DWB integration concept results in significantly lower environmental burdens when compared with production by the conventional BHP concept.

To use the results of this study in a decision making process it is recommended that this study be complemented by a risk assessment to consider the local environmental factors and thresholds.

Figure 4 - Comparison of BHP concept and DWB concept (characterised results)

Impact category	Unit	DWB Process	BHP Process	DWB impact vs BHP(%)
Aquatic acidification	KG SO_2 eq.	0.00873	0.334	3%
Aquatic ecotoxicity	KG TEG WATER	599	60600	1%
Aquatic eutrophication	KG PO4 P LIMITED	0.00119	0.0512	2%
Carcinogens	KG C_2H_3CL eq.	0.0419	0.283	15%
Global warming	KG CO_2 eq.	3.59	38.6	9%
Ionising radiation	BQ C-14 eq.	51.1	477	11%
Land occupation	M_2ORG.ARABLE	0.0487	9.1	1%
Mineral extraction	MJ SURPLUS	0.0623	0.435	14%
Non-carcinogens	KG C_2H_3CL eq.	0.0335	1.18	3%
Non-renewable energy	MJ PRIMARY	66.8	454	15%
Ozone layer depletion	KG CFC-11 eq.	0.000563	0.00417	14%
Respiratory inorganics	KG PM2.5 eq.	0.00152	0.0433	4%
Respiratory organics	KG C_2H_4 eq.	0.000991	0.00606	16%
Terrestrial acid/nutri	KG SO_2 eq.	0.034	1.06	3%
Terrestrial ecotoxicity	KG TEG SOIL	150	2660	6%

Figure 5 - Comparison of BHP concept and DWB concept (characterised results)



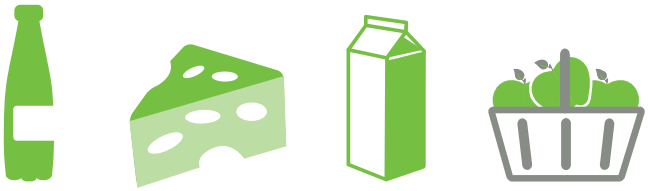
Danisco's commitment to sustainable production however goes further than Life Cycle Assessment. Customers' product performance is an important part of managing the total environmental impact. Collaborating with customers to drive further environmental and cost-saving benefits is important in creating sustainable products for the future.

4. What does this mean?

Food products, including growth of crops, transportation, processing, use and disposal, account for approximately 1/3 of total man-made greenhouse gas emissions. Meat typically has a high carbon footprint, with red meats higher than white meats due to methane emissions by ruminants. Vegetables tend to have a lower carbon footprint when compared with meat, although growing in a greenhouse does increase the total carbon emissions. Amongst the highest contributors to CO_2 emissions in the meat category is beef with an average emission rate of 20-40kg CO_2 eq/kg fresh meat. The carbon footprint of 1kg XIVIA™ (3.6kg CO_2 eq/kg) is similar to that of 1kg pork meat, ready to eat, whilst Xylitol produced with the BHP concept would equate to that of 11kg pork meat.

Dairy products have a relatively lower carbon footprint when compared with meat, with milk typically around 1kg CO_2 eq/kg finished product. Cheese is around 10 times higher at 10kg CO_2 eq/kg. This means that the emissions from the production of 1kg XIVIA™ equate to 3.6kg milk production or approximately 330g cheese production. For Xylitol produced by the conventional BHP concept these figures would be close to 40kg milk and 3.5kg cheese production, ten times higher than when compared with XIVIA™. (*Mat och Klimat;* Angervall et al: SIK Rapport Nr 776 2008).

The near future will see the proliferation of food companies publishing the carbon footprint of their products and using this on packaging. Some companies have already started to publish data. For example, a standard pack of flavoured crisps has a carbon footprint of 75g CO_2 eq, whilst a bar of chocolate (49g) has been calculated to have a carbon footprint of 169g CO_2 eq. The manufacture of 1kg of Xylitol from the BHP would equal the emissions from the production of 480 bags of crisps and 230 chocolate bars. In comparison, the production of 1kg XIVIA™ would have a similar carbon footprint to just 45 bags of crisps or 20 chocolate bars.



5. The future

The world faces unprecedented challenges. In the next 40 years, the world's population is projected to grow from 6.8 billion to 9 billion people. Economic pressures will lead to increased deforestation, an influx to large urban conurbations and the climate will change as a result of global warming.

How we address the demand for food availability, energy efficiency, reduced CO_2 emissions and better health & nutrition will be critical to the future of our industry, the world population and the planet.

6. People, planet and profit

We see these challenges as opportunities for our industry to make a positive difference. It is our job to enable solutions for some of these challenges through how we source our raw materials, produce our products and how we innovate to deliver more sustainable solutions.

For Danisco, sustainability is about finding innovative, sustainable solutions to help customers make products that provide lasting benefits to the society we live in, today and tomorrow.

7. Additional product benefits

XIVIA™ is a sustainable, naturally occurring sweetener with all the sweetness of sugar but with 40% less calories. It leaves no aftertaste which makes it an ideal ingredient for applications where taste, texture and mouthfeel are critical to a product's acceptance by end users.

It is the sweetest of all the naturally occurring polyols and is widely approved for use in food & beverages, oral hygiene products, cosmetics and pharmaceuticals worldwide.

- Meets consumers' demand for natural and sustainable products
- Proven to reduce the development of dental caries
- Reduces plaque formation
- Provides a natural, intense cooling effect
- Reduces the incidence of acute otitis media, the most common ear infection in children
- Complements fluoride in dental health products giving added protection in the fight against tooth decay
- Is safe for diabetics and individuals with hyperglycaemia
- Exhibits a low glycaemic index of 9 (GI 100 for glucose)
- Is safe for pregnant or nursing women
- Shows no known toxicity in humans

8. Status

Xylitol is widely approved for use in food around the world. It is also extensively approved for use in oral hygiene products, pharmaceuticals, cosmetics and toiletries.

In 1993, Xylitol was allocated an Acceptable Daily Intake of "not specified" by the Joint Expert Committee on Food Additives (JECFA), the safest category into which JECFA is able to place a food ingredient.

All grades of XIVIA™ from Danisco are derived from non-genetically modified raw material sources and no genetically modified organisms are used at any stage during the manufacturing process.

XIVIA™ has Kosher Pareve and Halal status and all production sites are accredited with 9001:2008 Quality Management systems. HACCP principles are followed at all XIVIA™ production sites, and XIVIA™ meets all of the requirements of the major pharmacopeia. Danisco has a first class safety record at all of our XIVIA™ productions plants, with a 'safety first' approach being adopted.

9. Becoming First choice

Danisco is the world's leading producer of food ingredients and among the strongest players in biotechnology. We have a heritage built on quality, trust, integrity and sound science.

People are the company's key ingredient for success and our strategic business asset. The experience, expertise and creativity our customers value is alive and well in the 6,800 people working at Danisco worldwide.

We will seize opportunities to partner with our customers and create sustainable solutions that meet their market needs. Our goal is to become a preferred supplier and partner – our customers' First choice.

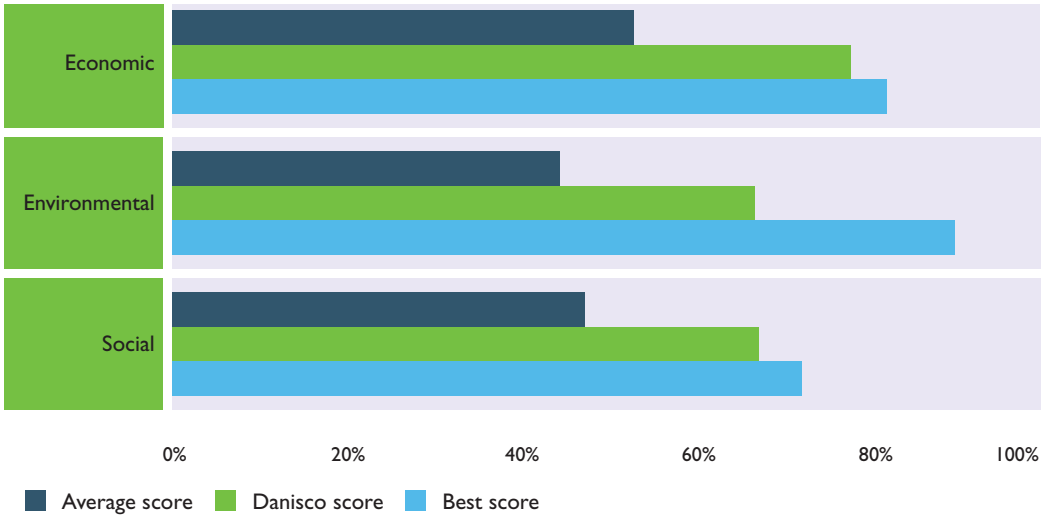
- We are trusted for the quality, consistency and security of supply of our Xylitol product. We have a reputation for regulatory and food application know-how. We form strategic partnerships with customers to meet the needs of the global food industry. We are in close cooperation with the scientific community and actively publish the findings of our proprietary research & development work.

- We collaborate closely with our customers all over the world. We have testing laboratories in many countries, so we can develop and test specific products, and tailor them to fit the local market.

- We offer a unique all-in-one approach; from concepts and claims to application technology and marketing partnerships.

Danisco is the only food ingredients company in the Dow Jones World food & beverage sector.

Figure 6 – Dow Jones Sustainability World Index 2010/2011



10. A more sustainable solution for customers and consumers

Overall, this study demonstrates that the environmentally superior performance of the DWB integration concept cannot be simply attributed to the use of the side stream as the feedstock because the side stream as a raw material carries substantial environmental burdens within itself. Instead the DWB concept on the whole is much more efficient, with a considerably lower use of materials and energy, in comparison to the BHP concept.

In addition to the more sustainable production process, XIVIA™ is also supported by Danisco's well-known regulatory and scientific expertise. Danisco is committed to a high level of customer service. Teams of dedicated speciality ingredients professionals are on hand to provide advice and assistance with all aspects of ingredient applications. They are experienced in a wide range of industries from confectionery and baking to oral care and pharmaceuticals.

XIVIA™ offers an ideal, more sustainable sugar substitute for customers who want to stay ahead and create sustainable products for tomorrow. Functional benefits, health claims, widespread acceptance and flexibility in various applications provide scope for creativity in product design, formulation and marketing campaign development.

For more information, please visit www.xivia.info

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